PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : G02C 7/04

A1

(11) International Publication Number: WO 91/09336

(43) International Publication Date: 27 June 1991 (27.06.91)

(21) International Application Number: PCT/US90/07229

(22) International Filing Date: 7 December 1990 (07.12.90)

(30) Priority data:

447,186	7 December 1989 (07.12.89)	US
447,201	7 December 1989 (07.12.89)	US

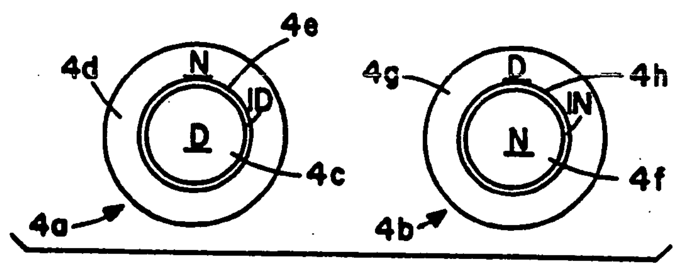
(71)(72) Applicant and Inventor: SEIDNER, Leonard [US/US]; 228 St. John's Place, Brooklyn, NY 11217 (US).

(74) Agent: COLEMAN, Henry, D.; Coleman & Sudol, 71 Broadway, Suite 1201, New York, NY 10006 (US).

(81) Designated States: AT (European patent), AU, BE (European patent), CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: CORNEAL CONTACT LENSES



(57) Abstract

In multifocal corneal contact lenses, the lenses of each pair (4a, 4b) have a different geometric configuration and/or distribution of focal zones (4c, 4d, 4e, 4f, 4g, 4h). The zones (4c, 4d, 4e, 4f, 4g, 4h) are distributed to provide vision corrections of different kinds for the two eyes of a patient under different illumination conditions. In monovision type corneal contact lenses, one or bothlenses (44a, 44b) is provided with one or more auxiliary correction zones (44e, 44h) each having a focal length different from the focal length of the major portion of the respective lenses. In any lens in accordance with the invention, the portion of the principal correction zones coextensive with the pupil of the respective eye covers more than approximately two-thirds (more preferably seventy-five percent and most preferably eighty percent) of the area of the pupil. This upper limit on the pupil area covered by the auxiliary zones is satisfied regardless of the disposition of the respective contact lens n the eye and regardless f the size of the respective pupil.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing internati nal applications under the PCT.

AT	Austria	FI	Finland	ML	Mali
AU	Australia	FR	France	MN	Mongolia
BB	Barbados	GA	Gabon	MR	Mauritania
BE	Belgium	GB	United Kingdom	MW	Malawi
BF	Burkina Faso	GN	Guinea	NL	Netherlands
BG	Bulgaria	GR	Greece	NO	Norway
BJ	Benin	HU	Hungary	PL	Poland
BR	Brazil	IT	Italy	RO	Romania
CA	Canada	JP	Japan	SD	Sudan
CF	Central African Republic	KP	Democratic People's Republic of Korea	SE	Sweden
CG	Congo			SN	Senegal
CH	Switzerland	KR	Republic of Korea	SU	Soviet Union
CI	Côte d'Ivoire	LI	Liechtenstein	TD	Chad
CM	Cameroon	LK	Sri Lanka	TG	Togo
DE	Germany	LU	Luxembourg	US	United States of America
DK	Denmark	MC	Monaco		
ES	Spain	MG	Madagascar		

CORNEAL CONTACT LENSES

Background of the Invention

This invention relates to corneal contact lenses and more particularly to multifocal and monovision type corneal contact lenses.

Multifocal and monovision type contact lenses are both designed to correct or compensate for a condition of advancing age known as "presbyopia." In a presbyopic eye, ability to focus at near distances, such as the normal reading distance, and in some cases at great distances is diminished. The loss of focusing capability is due to hardening of the eye's natural crystalline lens material.

Generally, multifocal contact lenses (usually either bifocal, trifocal or aspheric) are concentric or segmented in configuration. In a conventional bifocal contact lens of the concentric type, a first, centrally located, circular correction zone constitutes either distant or near vision correction, while a second annular correction zone surrounding the first zone provides the corresponding near or distance vision correction, respectively. In a conventional bifocal contact lens of the segmented type, the lens is divided into two somewhat D-shaped zones. Usually the upper area is for distant vision correction, whereas the lower area is for near vision correction. Such conventional segmented contact lenses require some sort of shifting of the lens relative to the eye to achieve acceptable visual acuity for both distant and near vision.

A trifocal contact lens has a third correction zone whose focal length is between the focal lengths of the distant vision and the near vision zones. The third correction zone may be termed a middle, or intermediate, distance correction zone.

Because of the multiplicity of foci, conventional multifocal contact lenses often produce a perceived image which is blurred. Such a situation worsens as illumination decreases, such as during night driving. With reduced illumination, the pupil enlarges in diameter, and consequently more light simultaneously enters the eye through both the distant vision correction zone and the near vision correction zone. This overlapping imagery increases the blur within the eye and reduces acuity and contrast of vision. The user's brain is usually not capable f ignoring the blurry portion of the

image in favor of the focused portion.

An alternative type of contact lens for correcting presbyopia is the monovision lens. A monovision lens is designed to focus only near objects or far objects on the retina. Thus, a patient provided with a distant vision contact lens for one eye (usually the dominant eye) and a near vision contact lens for the other eye uses the one eye to distinguish objects at a distance (for example, while driving) and the other eye for near vision (for example, reading). Although patients using monovision contact lenses are not seeing stereoscopically, typically visual tasks can be better performed with monovision lenses than with bifocal contact lenses. In addition, monovision lenses have a 75% success rate, much higher than the 25-35% success rate of conventional bifocal contact lenses. Despite the superior performance of monovision type contact lenses, they suffer from the disadvantage that the consuming public finds the loss of stereoscopic vision to be undesirable.

Objects of the Invention

An object of the present invention is to provide improved contact lenses for the correction of presbyopia.

Another object of the present invention is to provide improved pairs of multifocal corneal contact lenses.

Another, more particular, object of the present invention is to provide multifocal corneal contact lenses which minimize or avoid the above-mentioned disadvantage of multifocal contact lenses.

Yet a further object of the present invention is to provide improved monovision type corneal contact lenses.

Another particular object of the present invention is to provide such monovision type contact lenses which avoid the above-mentioned disadvantage of monovision type contact lenses.

Summary of the Invention

Pursuant to a general embodiment of the present invention, a pair of multifocal corneal contact lenses comprises a first contact lens for one eye of a patient and a second, differently configured lens for the ther eye of the patient. The first lens has a first distant vision correction

zone and a first near vision correction zone. The second contact lens has a first correction zone and a second correction zone, the first correction zone corresponding substantially in size, shape and location to the distant vision correction zone of the first contact lens, and the second correction zone corresponding substantially in size, shape and location to the near vision correction zone of the first contact lens. The first correction zone of the second contact lens constitutes a second near vision correction zone, the second correction zone constituting a second distant vision correction zone. Thus, in the second contact lens, the distant vision correction zone and the near vision correction zone are reversed with respect to the first contact lens. In addition, at least one of the two contact lenses has an intermediate distance correction zone separating the distant vision correction zone from the near vision correction zone of that lens.

Pursuant to another feature of the present invention, a plurality of intermediate distance correction zones may be disposed between the distant vision correction zone and the near vision correction zone of either or both of the contact lenses. Preferably, one of the intermediate distance correction zones of the first contact lens has a focal length in the same focal range as the focal length of one of the intermediate distance correction zones of the other contact lens. The other intermediate distance correction zone or zones of each lens may then have focal lengths ranges closer to the focal length of one or the other of the distant vision correction zone and the near vision correction zone of the respective lens.

The distant vision correction zones and near vision correction zones of the two lenses may have any of a number of different geometric configurations. For example, the correction zones may be concentrically arranged or may take D shapes (segmented lenses). More particularly, the first distant vision correction zone (first lens) may occupy a circular area and the first near vision correction zone (first lens) may occupy an annular area surrounding the first distant vision corr ction zone. Likewise, the s cond near vision correction zone (second lens) may occupy a circular area, while the sec-

ond distant vision correction zone occupies an annular area around the second near vision correction zone.

In a particular embodiment of the invention, each concentrically configured lens is provided with a plurality of annular intermediate distance correction zones between the circular inner zone and the annular outer zone. One of the intermediate distance correction zones in any particular lens may take the form of an intermediate-distant vision correction zone, while another intermediate distance vision correction zone may take the form of an intermediate-near vision correction zone. Alternatively or in addition, a true intermediate distance correction zone may be provided.

Pursuant to yet another feature of the present invention, the centrally located, circular correction zone of a concentrically configured lens, whether a distant vision correction zone or a near vision correction zone, has an area equal to approximately two-thirds of a minimum area (high illumination) subtended by the respective pupil of the patient. In addition, in a lens having at least two correction zones, it is advantageous if that portion of the outer, annular correction zone coextensive with the pupil in a maximally opened state thereof occupies an area equal to at least two-thirds of the area of the pupil in its maximally opened state (low illumination).

In accordance with another general embodiment of the present invention, a pair of multifocal corneal contact lenses includes a first contact lens for one eye of a patient, the lens having a distant vision correction zone, a near vision correction zone and an intermediate distance correction zone. A second contact lens for the other eye of the patient has a first correction zone, a second correction zone and a third correction zone, wherein the first correction zone corresponds generally in shape and location to the distant vision correction zone of the first contact lens, the second correction zone corresponds generally in shape and location to the near vision correction zone of the first contact lens, and the third correction zone corresponds generally in shape and location to the intermediate distance correction zone of the first contact lens. One of the correction zones of the second lens

has a focal length in the same focal range as the focal length of the corresponding zone of the first contact lens, whereas the other two correction zones each have a focal length in the same focal range as the other of the remaining two zones of the first contact lens, whereby those other two zones are switched with respect to the first contact lens.

The zone which is in the same focal range and has the same relative geometric location in the two lenses may be a distant vision correction zone, a near vision correction zone or an intermediate distance correction zone and may be, in a concentrically configured lens, a circular centrally located correction zone, an annular middle correction zone or an annular outer correction zone. In most specific applications, the first correction zone, the second correction zone and the third correction zone have relative sizes different from relative sizes of the distant vision correction zone, the near vision correction zone and the intermediate distance correction zone.

Pursuant to a first specific form of the invention, both lenses have a distant vision correction zone in the shape of a circular region at the center of the respective lens. In that case, one lens has an annular outer area which is a near vision correction zone and an annular middle area which is an intermediate distance correction zone; the other lens has an outer annular area which is an intermediate distance correction zone and an annular middle area which is a near vision correction zone. Alternatively, the circular central region in both lenses may be an intermediate distance correction zone (or a near vision correction zone), while the outer annular correction zone of one lens is a near vision correction zone (or a distant vision correction zone) and the outer correction zone of the other lens is an intermediate distance correction zone.

In another specific form of the invention, the middle (annular) correction zones in the two lenses have focal lengths in a common focal range, while the focal lengths of the circular central zone and of the outer, annular z ne are switched from the one l ns to the other. Thus, if th middle zone in both lens s is an intermediate distance correction

zone, the central zone of one lens is a near vision correction zone and the central zone of the other lens is a distant vision correction zone and vice versa for the outer, annular zones. Alternatively, the middle, annular zone of both lenses may be either a distant vision correction zone or a near vision correction zone.

In yet another specific form of the invention, the outer (annular) vision correction zones of the two lenses have focal lengths in a common focal range, and the focal lengths of the circular central zone and of the inner, annular zone are switched from the one lens to the other. Thus, if the outer zone in both lenses is a distant vision correction zone, the central zone of one lens is a near vision correction zone and the central zone of the other lens is an intermediate distance correction zone and vice versa for the inner, annular zones. Alternatively, the outer, annular zone of both lenses may be either a near vision correction zone or an intermediate distance correction zone.

In accordance with yet another general embodiment of the present invention, a pair of multifocal corneal contact lenses comprises a first contact lens for one eye of a patient, the lens having a first correction zone and a second correction zone concentrically disposed with respect to one another, and a second contact lens for the other eye of the patient, the second contact lens having a third correction zone and a fourth correction zone concentrically disposed with respect to one another. The first correction zone and the third correction zone are each circular, while the second and the fourth correction zone are each annular in plan view of the respective contact lens. The first correction zone and the fourth correction zone each constitutes a distant vision correction zone, whereas the second correction zone and the third correction zone each constitutes a near vision correction zone. The first correction zone and the third correction zone each have an area equal to approximately two-thirds of a minimum area subtended by the respective pupil of the patient.

Pursuant t another feature of the invention, a porti n of the second correcti n zone and a porti n of the f urth correcti n zone coextensive with the pupil of the respective

eye in a maximally opened state of such pupil each cover an area equal approximately to at least two-thirds of the area subtended by the respective pupil in the maximally opened state. In some cases, the second correction zone is immediately adjacent the first correction zone and the fourth correction zone is immediately adjacent the third correction zone. In other cases, the first contact lens has a first annular intermediate distance correction zone between the first correction zone and the second correction zone, and the second contact lens has a second annular intermediate distance correction zone disposed between the third correction zone and the fourth correction zone.

In a pair of contact lenses pursuant to this general embodiment of the present invention, one lens is a near vision lens and the other is a distant vision lens during periods of high illumination (minimum pupil size), while the lenses reverse function during periods of low illumination (maximum pupil size) so that the first lens then functions as a distant vision correction lens and the second lens functions as a near vision correction lens. The limitations on pupil area subtended by the correction zones during extremes of ambient illumination minimizes blurring and optimizes visual acuity. During periods of intermediate and low illumination, vision is also, to some extent, stereoscopic.

A pair of multifocal corneal contact lenses comprises, in accordance with yet another embodiment of the present invention, a first contact lens for one eye of a patient and a second contact lens for the other eye of the patient. The first lens has a first correction zone and second correction zone, the first correction zone having a focal length in a first focal range and the second correction zone having a focal length in a second focal range. The second contact lens has a third correction zone and a fourth correction zone, the third correction zone corresponding generally in shape and location to the first correction zone, the fourth correction zone corresponding generally in shape and location to the second correction zone. The third c rrection zone has a focal length in the second focal range and the fourth correction z ne has a focal length in the first focal range. At least

one of the contact lenses has on an anterior side a continuous surface with essentially a single radius of curvature and is provided on a posterior side with a cornea matching surface extending annularly along a periphery of the lens. That posterior side is further formed with at least one concave surface having a radius of curvature smaller than any radius of curvature of the cornea matching surface, the concave surface being radially spaced from a geometric center of the lens.

In accordance with a general embodiment of the present invention, a pair of monovision type corneal contact lenses comprises a first contact lens for one eye of a patient, that lens having a first distant vision correction zone and a second distant vision correction zone separated from one another by an auxiliary correction zone. The distant vision correction zones have a common focal length, while the auxiliary correction zone has another focal length different from the distant vision correction zone focal length. A second contact lens, for the other eye of the patient, has a first near vision correction zone and a second near vision correction zone separated from one another by another auxiliary correction zone. The near vision correction zones of the second contact lens have their own common focal length, while the auxiliary correction zone of the second contact lens has a focal length different from the focal length of the near vision correction zones of the second lens.

Preferably, the auxiliary correction zones of the two contact lenses are intermediate distance correction zones. In some applications, it may be preferable that the auxiliary correction zone of the first lens is an intermediate-distant vision correction zone, while the auxiliary correction zone of the other lens is an intermediate-near vision correction zone. In such cases, the focal length of an auxiliary correction zone is closer than it would otherwise be to the focal length of the other correction zones of the respective lens.

As described hereinafter, the auxiliary correction zones are limited in size relative t the principal correction zones of the respective lenses. In this way, the advantages of mon vision are retained, while additi nal benefits are pro-

vided by virtue of the inclusion of the auxiliary correction zones.

In some applications, it is advantageous that the focal lengths of the auxiliary correction zones of the two lenses are in essentially the same focal range.

Pursuant to an alternative specific feature of the present invention, the auxiliary correction zone of the first lens is a near vision correction zone. Alternatively, the auxiliary correction zone of the second lens is a distant vision correction zone. In either of these cases, the focal length of an auxiliary correction zone is closer than it would otherwise be to the focal length of the non-auxiliary correction zones of the other lens. Specifically, the auxiliary correction zone of the first lens may be a near vision correction zone with a focal length in a range in which the focal length of the near vision correction zones of the second lens falls. Similarly, the auxiliary correction zone of the second lens may be a distant vision correction zone.

The distant vision correction zones of the first lens and the near vision correction zones of the second lens may have any of a number of different geometric configurations. For example, the correction zones may be concentrically arranged or may take D shapes (segmented lenses). More particularly, the first distant vision correction zone (first lens) may occupy a circular area and the second distant vision correction zone (first lens) may occupy an annular area surrounding the distant vision correction zone, the auxiliary correction zone of the first contact lens occupying an essentially annular area between the two distant vision correction zones. Likewise, the first near vision correction zone (second lens) may occupy a circular area, while the second near vision correction zone occupies an annular area about the second near vision correction zone and the auxiliary correction zone of the second lens takes an annular form between the two near vision correction zones.

In a particular embodiment of the invention, each concentrically configured lens may be provided with a plurality of annular auxiliary distance correction zones b tween the circular inner zone and the annular outer zone.

One or the auxiliary correction zones in the first lens may take the form of an intermediate-distant vision correction zone, while another auxiliary correction zone may take the form of a true intermediate distance correction zone or a near vision correction zone. In that case, the focal length of the intermediate distance correction zone is shorter than the focal length of the intermediate-distant vision correction zone which is, in turn, smaller than the focal length of the distant vision correction zones. Similarly, in the second lens, one auxiliary correction zone may be a true intermediate distance correction zone, while another auxiliary correction zone is an intermediate-near vision correction zone or even an intermediate-distant vision correction zone.

Pursuant to yet another feature of the present invention, the centrally located, circular correction zone of a concentrically configured lens, whether it is a distant vision correction zone or a near vision correction zone, has an area equal to approximately two-thirds of a minimum area subtended by the respective pupil of the patient. In addition, in a lens having three zones or more, where the outermost annular zone has essentially the same focal length as the inner, circular correction zone, it is advantageous that the inner correction zone and the portion of the outermost annular correction zone coextensive with the pupil in a maximally opened state thereof together occupy an area equal to at least two thirds of the area of the respective pupil in the maximally opened state thereof.

With respect to a specific form of the present invention, the distant vision correction zones of the first lens and the near vision correction zones of the second lens are all essentially D-shaped in a plan view of the two contact lenses. In that case, the auxiliary correction zones of the two lenses are essentially strip-shaped. One or more additional strip-shaped auxiliary correction zones may be disposed in each lens between the distant vision correction zones (first lens) or the near vision correction zones (second lens) thereof. One of the plurality of auxiliary correction zones may be an intermediate distance correction zone, while another auxiliary correction zone is, f r example, a distant vision

correction zone, a near vision correction zone, an intermediate-distant vision correction zone or an intermediate-near vision correction zone. Preferably, an auxiliary correction zone of one contact lens has a focal length in the same focal range (e.g., distant, intermediate-distant, intermediate, intermediate-near, near) as a corresponding auxiliary correction zone of the other contact lens.

In accordance with another general embodiment of the present invention, a pair of monovision type corneal contact lenses comprises a distant vision contact lens for one eye of a patient, the lens having a distant vision correction zone extending throughout a major portion of the lens. The distant vision correction zone has a characteristic focal length. The lens also has at least one first auxiliary correction zone with a respective focal length different from the focal length of the distant vision correction zone. The portion of the distant vision correction zone coextensive with the pupil of the one eye covers more than approximately two-thirds (more preferably 75% and most preferably 80%) of the area of the pupil of the one eye, essentially irrespective of the disposition of the contact lens on the eye and of size of the pupil. A near vision contact lens for the other eye of the patient has a near vision correction zone extending throughout a major portion of the near vision lens. The near vision correction zone has a characteristic focal length. The near vision lens, in addition, has at least one auxiliary correction zone with a focal length different from the focal length of the near vision portion of the lens. The portion of the auxiliary correction zone of the near vision lens coextensive with the pupil of the respective eye covers more than approximately two-thirds (more preferably 75% and most preferably 80%) of the area of that pupil, essentially irrespective of the disposition of the near vision contact lens on the eye and of the size of the respective pupil.

Pursuant to this general embodiment of the invention, the light falling n the retina of either eye through the auxiliary correction zone or zones of the respective contact lens is limited at any and all times to one-third (more

preferably 25% and most preferably 20%) of the total incident radiation.

Pursuant to a specific feature of the invention, the auxiliary correction zone or zones of one lens of a monovision pair correspond substantially in size, shape and location to the auxiliary correction zone or zones of the other member of the pair. The auxiliary correction zones may be, for example, annular, crescent shaped, or rectangular. They may both be intermediate distance vision correction zones.

An advantage of monovision type contact lenses in accordance with the present invention is that they may be marketed as bifocal or even trifocal lenses. That makes the lenses more desirable than conventional monovision lenses to the consuming public. The benefits of monovision are retained, while the user is able to see stereoscopically in at least a limited (e.g., intermediate distance) focal range.

A corneal contact lens pursuant to a general feature of the present invention has a first vision correction zone with a first focal length and at least one second vision correction zone with a second focal length different from the first focal length. The lens has on an anterior side a continuous surface with essentially a single radius of curvature and is provided on a posterior side with a cornea matching surface extending annularly along a periphery of the lens. The posterior side is further formed with at least one concave surface having a radius of curvature smaller than any radius of curvature of the cornea matching surface, the concave surface being spaced from a geometric center of the lens.

Brief Description of the Drawing

Figs. 1 through 12 are plan views of pairs of multifocal contact lenses in accordance with a general embodiment of the present invention.

Fig. 13, 14 and 15 are plan views of further pairs of multifocal contact lenses in accordance with the present invention.

Figs. 16 through 23 and 26 through 33 are plan views of pairs of multifocal contact lenses in accordance with another general embodiment of the present invention.

Figs. 24, 25 and 34 through 36 are plan views of

additional pairs of multifocal contact lenses in accordance with the present invention.

Fig. 37 is a cross-sectional view taken along line A-A in Fig. 1.

Fig. 38 is a cross-sectional view taken along line B-B in Fig. 1.

Fig. 39 is a cross-sectional view taken along line C-C in Fig. 2.

Fig. 40 is a cross-sectional view taken along line E-E in Fig. 2.

Fig. 41 is a cross-sectional view taken along line F-F in Fig. 8.

Fig. 42 is a cross-sectional view taken along line G-G in Fig. 15.

Fig. 43 is a plan view of a pair of generally monovision type contact lenses in accordance with a general embodiment of the present invention.

Figs. 44 through 52 are plan views of further pairs of generally monovision type contact lenses in accordance with the present invention.

Fig. 53 is a plan view of another pair of generally monovision type contact lenses in accordance with the present invention.

Fig. 54 is a plan view of yet another pair of generally monovision type contact lenses in accordance with the present invention.

Fig. 55 is a plan view of yet another pair of generally monovision type contact lenses in accordance with the present invention.

Fig. 56 is a plan view of another pair of generally monovision type contact lenses in accordance with the present invention.

Fig. 57 is a cross-sectional view taken along line H-H in Fig. 2.

Fig. 58 is a cross-sectional view taken along line J-J in Fig. 2.

Fig. 59 is a cross-sectional view taken al ng line K-K in Fig. 4.

Fig. 60 is a cross-sectional view taken along line

L-L in Fig. 4.

Figs. 61 through 64 are plan views of additional pairs of generally monovision type contact lenses in accordance with another general embodiment of the present invention.

Figs. 65 through 67 are plan views of generally monovision type contact lenses in accordance with yet another general embodiment of the present invention.

Detailed Description

Drawing figures 1 through 42 illustrate pairs of corneal contact lenses with members having multiple correction zones which differ in configuration from one to the other to provide improved multifocal type corrections for presbyopia. One member of each pair is intended for one eye of a patient, while the other member is intended for the other eye.

Figs. 1 through 12 all illustrate multifocal contact lenses wherein a first contact lens of a pair has a first distant vision correction zone and a first near vision correction zone in a pre-established configuration and a second contact lens of the pair has at least a first correction zone and a second correction zone, wherein the first correction zone corresponds at least generally in shape and location to the distant vision correction zone of the first contact lens and the second correction zone corresponds at least generally in shape and location to the near vision correction zone of the first contact lens, and wherein the first correction zone constitutes a second near vision correction zone and the second correction zone constitutes a second distant vision correction zone.

It is to be noted that, for purposes of simplifying the drawing, the plan views of Figs. 1 through 36 have omitted a representation of an annular peripheral cornea matching zone included in each lens pursuant to conventional lens design. These corneal matching areas are shown in the cross-sectional views of Figs. 37 through 42.

As shown in Fig. 1, a first contact lens 1a of a pair of multifocal corneal contact lenses includes a circular distant vision correction zone 1c surrounded by an annular near vision correction zone 1d. A second contact lens 1b of the pair includes a circular near vision c rrection zone 1e

surrounded by an annular distant vision correction zone 1f.

Fig. 2 illustrates a pair of multifocal corneal contact lenses 2a and 2b, wherein the first lens 2a includes a circular distant vision correction zone 2c and an annular, outer near vision correction zone 2d separated by an annular middle intermediate distance correction zone 2e. The second lens 2b of the pair also includes three correction zones 2f, 2g and 2h arranged concentrically with respect to one another. Circular center zone 2f is a near vision correction zone, whereas outer zone 2g is a distant vision correction zone and middle zone 2h is an intermediate distance correction zone. Correction zones 2e and 2h have focal lengths which are in the same range (the intermediate distance correction zone range).

Fig. 3 depicts a pair of multifocal corneal contact lenses 3a and 3b wherein lens 3a is identical to lens 2a and thus includes a circular distant vision correction zone 3c and an annular, outer near vision correction zone 3d separated by an annular middle intermediate distance correction zone 3e. Lens 3b is identical to lens 1b and thus includes a circular near vision correction zone 3f surrounded by an annular distant vision correction zone 3g.

Preferably, the inner, circular correction zones 1c, 1e, 2c, 2f and 3c, 3f of the lenses shown in Figs. 1 through 3 each have an area equal to at least two-thirds (preferably seventy-five percent and most preferably eighty percent) of a minimum area subtended by the respective pupil of the patient. This area distribution is believed to optimally minimize blurring during periods of high illumination.

Lens 1a is a distant vision lens for high illumination and a near vision lens for low illumination. The reverse applies to lens 1b: it is a near vision lens at high levels of illumination and a distant vision lens at low illumination. In order to optimize visual acuity in those lenses, it is also recommended that the portion of each of the outer zones 1d and 1f coextensive with the pupil of the respective eye during periods of low illumination covers at least approximately two-thirds of the respective pupil (preferably seventy-five percent and most preferably eighty percent).

Similarly, lenses 2a and 3a are distant vision

lenses for high illumination and near vision lenses in situations of low illumination, while lenses 2b and 3b are near vision lenses in situations of high illumination and distant vision lenses during periods of low illumination. Near vision correction zones 2d and 3d and distant vision correction zones 2g and 3g should be so dimensioned, for purposes of maximizing visual acuity, that the portion of each of those outer zones 2d, 3d, 2g, and 3g coextensive with the pupil of the respective eye during periods of low illumination covers at least approximately two-thirds of the respective pupil (preferably seventy-five percent and most preferably eighty percent).

Fig. 4 illustrates a pair of multifocal corneal contact lenses 4a and 4b, wherein the first lens 4a includes a circular distant vision correction zone 4c and an annular, outer near vision correction zone 4d separated by an annular middle intermediate-distant vision correction zone 4e. The second lens 4b of the pair also includes three correction zones 4f, 4g and 4h arranged concentrically with respect to one another. Circular center zone 4f is a near vision correction zone, whereas outer zone 4g is a distant vision correction zone and middle zone 4h is an intermediate-near vision correction zone. Correction zones 4e and 4h advantageously have focal lengths which are generally closer to the focal lengths of the respective inner zones 4c and 4f than the focal lengths of intermediate distance correction zones 2e and 2h are to the focal lengths of inner zones 2c and 2f, respectively.

The discussion hereinabove with respect to the sizes of the inner and outer correction zones of the lenses of Figs. 1 through 3 also applies to the multifocal corneal contact lenses illustrated in Fig. 4.

As illustrated in Fig. 5, one contact lens 5a has a circular innermost correction zone 5c separated from an annular outermost correction zone 5d by two annular middle correction zones 5e and 5f. Innermost and outermost zones 5c and 5d take the form of a distant vision correction zone and a near vision correcti n zone respectively, while annular middle zones 5e and 5f are an intermediate-distant vision correction zone and a true intermediate distance correction zone, respec-

tively. Thus, the focal length of middle zone 5f is shorter than the focal length of middle zone 5e.

Similarly, second contact lens 5b of the pair shown in Fig. 5 has a circular innermost correction zone 5g separated from an annular outermost correction zone 5h by two annular middle correction zones 5i and 5j. Innermost and outermost zones 5g and 5h are a near vision correction zone and a distant vision correction zone, respectively, while annular middle zones 5i and 5j are an intermediate-near vision correction zone and a true intermediate distance correction zone, respectively. The focal length of middle zone 5j is longer than the focal length of middle zone 5i.

Fig. 6 depicts a pair of multifocal corneal contact lenses 6a and 6b wherein lens 6a has a circular innermost correction zone 6c separated from an annular outermost correction zone 6d by three annular middle correction zones 6e, 6f and 6g. Innermost and outermost zones 6c and 6d are respectively a distant vision correction zone and a near vision correction zone. Annular middle zones 6e and 6g are an intermediate-distant vision correction zone and a intermediate-near vision correction zone, respectively. Middle zone 6f is a true intermediate distance correction zone. Thus, the focal length of middle zone 6f is shorter than the focal length of middle zone 6e and longer than the focal length of middle zone 6g.

Similarly, second contact lens 6b of the pair shown in Fig. 6 has a circular innermost correction zone 6h separated from an annular outermost correction zone 6i by three annular middle correction zones 6j, 6k and 6m. Innermost and outermost zones 6h and 6i are a near vision correction zone and a distant vision correction zone, while annular middle zones 6j and 6m are an intermediate-near vision correction zone and an intermediate-distant vision correction zone. Middle zone 6k is a true intermediate distance correction zone, the focal length of middle zone 6k being longer than the focal length of middle zone 6j and shorter than the focal length of intermediate distance correction zone 6m.

In a preferred embodiment f the present invention, the middle correction zones 6e, 6f, 6g, 6j, 6k and 6m have a radial dimension or width substantially thinner than the

radial dimension of outer correction zones 6d and 6i or the radii of inner correction zones 6c and 6h. Such relative dimensions are preferred in order to optimize visual acuity, as discussed hereinabove. Moreover, it is to be noted that the relative widths of the correction zones of one lens 6a may be, depending on the application (e.g., the particular patient's condition), different than the relative widths of the correction zones of the other lens 6b.

As shown in Fig. 7, in a pair of multifocal corneal contact lenses 7a and 7b, a first lens 7a has a D-shaped distant vision correction zone 7c disposed above a D-shaped near vision correction zone 7d. Another lens 7b has a D-shaped near vision correction zone 7e disposed above a D-shaped distant vision correction zone 7f.

In a more preferred specific embodiment of the invention, illustrated in Fig. 8, a first lens 8a includes an upper, D-shaped distant vision correction zone 8c separated by a strip-shaped intermediate distance correction zone 8e from a lower, D-shaped near vision correction zone 8d. A second lens 8b comprises an upper, D-shaped near vision correction zone 8f separated by a strip-shaped intermediate distance correction zone 8h from a lower, D-shaped distant vision correction zone 8g.

In a pair of multifocal corneal contact lenses 9a and 9b shown in Fig. 9, a first lens 9a is identical to lens 7a while another lens 9b is identical to lens 8b. Accordingly, lens 9a includes a D-shaped distant vision correction zone 9c disposed above a D-shaped near vision correction zone 9d, while lens 9b includes an upper, D-shaped near vision correction zone 9e separated by a strip-shaped intermediate distance correction zone 9g from a lower, D-shaped distant vision correction zone 9f.

In another specific embodiment of the invention, illustrated in Fig. 10, a first lens 10a includes an upper, D-shaped distant vision correction zone 10c separated by a strip-shaped intermediate-distant vision correction zone 10e from a lower, D-shaped near vision correction zone 10d. A second lens 10b comprises an upp r, D-shaped near visi n correction zone 10f separated by a strip-shaped intermediate-near

vision correction zone 10h from a lower, D-shaped distant vision correction zone 10g.

Fig. 11 is an illustration of a first contact lens 11a having two substantially D-shaped terminal correction zones 11c and 11d and two substantially strip-shaped correction zones 11e and 11f between D-shaped zones 11c and 11d. A second contact lens of the pair includes two substantially D-shaped terminal correction zones 11g and 11h and substantially strip-shaped correction zones 11i and 11j between D-shaped zones 11g and 11hi.

D-shaped zones 11c and 11h are distant vision correction zones, while D-shaped zones 11d and 11g are near vision correction zones. Zones 11e and 11j are intermediate-distant vision correction zones, while zones 11f and 11i are intermediate-near vision correction zones. For example, distant vision correction zones 11c and 11h may a substantially the same focal length, depending on the focal powers of the respective eyes of the patient. Likewise, intermediate-near vision correction zones 11f and 11i may have the same focal length, if required by the eyes of the patient.

As depicted in Fig. 12, a pair of multifocal corneal contact lenses 12a and 12b includes a first contact lens 12a having a D-shaped distant vision correction zone 12c and a D-shaped near vision correction zone 12d separated from one another by three substantially strip-shaped correction zones 12e, 12f and 12g. A second contact lens 12b of the pair includes a D-shaped near vision correction zone 12h and a D-shaped distant vision correction zone 12i separated from one another by three substantially strip-shaped correction zones 12j, 12k and 12m.

Zones 12e and 12g are an intermediate-distant vision correction zone and an intermediate-near vision correction zone, respectively, while zones 12j and 12m are an intermediate-near vision correction zone and an intermediate-distant vision correction zone, respectively. Middle zones 12f and 12k are intermediate distance correction zones. Middle zone 12f has a focal length less in value than a focal length of intermediate-distant vision correction zone 12e and greater in value than the focal length of intermediate-near

vision correction zone 12g. Middle zone 12k has a focal length less in value than a focal length of intermediate-distant vision correction zone 12m and greater in value than the focal length of intermediate-near vision correction zones 12j.

A pair of multifocal corneal contact lenses 13a and 13b shown in Fig. 13 include a first lens 13a identical to lens 3a and a second lens 13b identical to lens 8a. Thus, lens 13a includes a circular distant vision correction zone 13c and an annular, outer near vision correction zone 13d separated by an annular middle intermediate distance correction zone 13e, while lens 13b includes an upper, D-shaped distant vision correction zone 13f separated by a strip-shaped intermediate distance correction zone 13h from a lower, D-shaped near vision correction zone 13g

Fig. 14 shows a first contact lens 14a having a circular intermediate distance correction zone 14e at the center. A substantially D-shaped distant vision correction zone 14c is on an upper side of zone 14e opposite a near vision correction zone 14d. Distant vision correction zone 14c and near vision correction zone 14d are partially separated from one another by intermediate distance correction zone 14e and are contiguous with one another along a line on opposite sides of zone 14e.

In a second lens 14b of the pair shown in Fig. 14, a circular intermediate distance correction zone 14h is disposed at the center of the lens between a substantially D-shaped near vision correction zone 14f on an upper side of the lens and a distant vision correction zone 14g on a lower side of the lens. Near vision correction zone 14f and distant vision correction zone 14g are partially separated from one another by intermediate distance correction zone 14h and are contiguous with one another along a line on opposite sides of zone 14h.

As depicted in Fig. 15, in a pair of multifocal corneal contact lenses 15a and 15b, a first lens 15a has a circular distant vision correction zone 15e disposed between an upper D-shaped intermediate distance correction zone 15c and a lower D-shaped near vision correction zone 15d. In a

second lens 15b, a circular near vision correction zone 15h is disposed between an upper D-shaped intermediate distance correction zone 15f and a lower D-shaped distant vision correction zone 15g.

Figs. 16 through 30 all illustrate multifocal contact lenses wherein a first contact lens has a distant vision correction zone, a near vision correction zone and an intermediate distance correction zone, while a second contact lens has a first correction zone, a second correction zone and a third correction zone, the first correction zone corresponding substantially in size, shape and location to the distant vision correction zone of the first contact lens, the second correction zone corresponding substantially in size, shape and location to the near vision correction zone of the first contact lens, and the third correction zone corresponding in size, shape and location to the intermediate distance correction zone of the first contact lens. One of the correction zones of the second contact lens has a focal length in the same focal range as the focal length of the corresponding zone of the first contact lens. More particularly stated, two contact lens zones which have the same geometry and position in the two lenses are both distant vision correction zones, intermediate distance correction zones or near vision correction zones. The other two zones of the second lens are reversed with respect to the first lens: if the remaining zones of the first lens are termed "P" and "Q" and the geometrically corresponding zones of the second lens are respectively termed "P′" and "Q,′" the focal lengths of zones P and Q′ lie in the same focal range (i.e., both such zones are distant vision correction zones, intermediate distance correction zones or near vision correction zones), while the focal lengths of zones P′ and Q lie in the same range.

Fig. 16 illustrates a pair of multifocal corneal contact lenses 16a and 16b, wherein the first lens 16a includes a circular distant vision correction zone 16c and an annular, outer near vision correction zone 16d separated by an annular middle intermediate distance correction zone 16e. In contrast, the second lens 16b includes a circular distant vision correcti n zone 16f at the center of the lens and an

annular, outer intermediate distance correction zone 16g separated by an annular middle near vision correction zone 16h.

In contact lenses 16a and 16d, intermediate distance correction zones 16e and 16g are preferably substantially thinner (radial dimension) than near vision correction zones 16d and 16h. By way of example, intermediate distance correction zones 16e and 16g may have widths of a fraction of a millimeter, while near vision correction zones 16d and 16h may have widths up to several millimeters. Thus, it is clear that the relative widths of correction zones 16c, 16d and 16e may be different from the relative widths of correction zones 16f, 16g and 16h.

As shown in Fig. 17, a pair of multifocal corneal contact lenses 17a and 17b includes a first contact lens 17a with a circular near vision correction zone 17c at the center of the lens and an annular intermediate distance correction zone 17d at the periphery of the lens. Near vision correction zone 17c and intermediate distance correction zone 17d are spaced from one another by an annular distant vision correction zone 17e. The second lens 17b of the pair also includes three correction zones 17f, 17g and 17h arranged concentrically with respect to one another. Circular center zone 17f is a near vision correction zone, whereas outer zone 17g is a distant vision correction zone and middle zone 17h is an intermediate distance correction zone.

The correction zones of lenses 17a and 17b may have relative widths which vary from lens to lens. In particular, intermediate distance correction zonez 17d and 17h will generally have widths which are several times smaller than the widths of distant vision correction zones 17e and 17g.

In a pair of multifocal corneal contact lenses 18a and 18b depicted in Fig. 18, a first lens 18a comprises a circular intermediate distance correction zone 18c at the geometric center of the lens, an annular distant vision correction zone 18d at the outer edge of the lens, and an annular near vision correction zone 18e separating the circular center zone from the annular peripheral zone. The second lens 18b has a circular inner zone 18f in the form of an intermediate distance correction zone, an annular peripheral zone 18g in the

form of a near vision correction zone, and an annular middle zone 18h in the form of a distant vision correction zone. In the embodiment illustrated in Fig. 18, the centrally located, intermediate distance correction zones 18c and 8f are generally substantially smaller than the annular correction zones 18d, 18e and 18g and 18h.

A first contact lens 19a of pair of multifocal corneal contact lenses 19a and 19b illustrated in Fig. 19 includes three concentric vision correction zones 19c, 19d and 19e. The first zone 19c, located at the center of the lens, is a near vision correction zone, while the second zone 19d, located at the edge of the lens, is an intermediate distance correction zone and the third zone 19e, located between the first two, is a distant vision correction zone. The second lens 19b of the pair includes a circular intermediate distance correction zone 19f at the center of the lens and two surrounding ring-shaped zones 19g and 19h. Outer ring 19g is a near vision correction zone, whereas inner ring 19h is a distant vision correction zone.

Fig. 20 illustrates a pair of multifocal corneal contact lenses 20a and 20b, wherein the first lens 20a includes a circular distant vision correction zone 20c and an annular, outer intermediate distance correction zone 20d separated by an annular middle near vision correction zone 20e. In contrast, the second lens 20b includes a circular intermediate distance correction zone 20f at the center of the lens and an annular, outer distant vision correction zone 20g separated by an annular middle near vision correction zone 20h.

As shown in Fig. 21, a pair of multifocal corneal contact lenses 21a and 21b includes a first contact lens 21a with a circular near vision correction zone 21c at the center of the lens and an annular distant vision correction zone 21d at the periphery of the lens. Near vision correction zone 21c and distant vision correction zone 21d are spaced from one another by an annular intermediate distance correction zone 21e. The second lens 21b of the pair also includes three correction zon s 21f, 21g and 21h arranged concentrically with respect to one another. Circular center zone 21f is an intermediate distance correction zone, whereas outer zone 21g is a

distant vision correction zone and middle zone 21h is a near vision correction zone.

In a pair of multifocal corneal contact lenses 22a and 22b depicted in Fig. 22, a first lens 22a comprises a circular intermediate distance correction zone 22c at the geometric center of the lens, an annular near vision correction zone 22d at the outer edge of the lens, and an annular distant vision correction zone 22e separating the circular center zone from the annular peripheral zone. The second lens 22b has a circular inner zone 22f in the form of a distant vision correction zone, an annular peripheral zone 22g in the form of a near vision correction zone, and an annular middle zone 22h in the form of an intermediate distance correction zone.

A first contact lens 23a of pair of multifocal corneal contact lenses 23a and 23b illustrated in Fig. 23 includes three concentric vision correction zones 23c, 23d and 23e. The first zone 23c, located at the center of the lens, is a near vision correction zone, while the second zone 23d, located at the edge of the lens, is an intermediate distance correction zone and the third zone 23e, located between the first two, is a distant vision correction zone. The second lens 23b of the pair includes a circular distant vision correction zone 23f at the center of the lens and two surrounding ring-shaped zones 23g and 23h. Outer ring 23g is an intermediate distance correction zone, whereas inner ring 23h is a near vision correction zone.

Preferably, the inner, circular correction zones 16c, 16f, 17c, 17f, 19c, 20c, 21c, 22f, 23c and 23f of the lenses shown in Figs. 16 through 23 each have an area equal to approximately two-thirds of a minimum area subtended by the respective pupil of the patient. As stated above, this area distribution is believed to optimally minimize blurring during periods of high illumination. Lenses 16a, 16b, 20a, 22b, and 23b are distant vision lens during periods of high illumination, while lenses 17a, 17b, 19a, 21a, and 23a are near vision lenses in high illumination situations.

In at least some of those lenses, visual acuity of either distant vision or near vision, whichever kind of vision is n t aided by the central correction z ne, is optimized in

periods of low illumination by controlling the relative size of the annular outer correction zones. For example, distance vision during low illumination is maximized in lens 17b, 18a, 20b, 21a and 21b by ensuring that the portion of each of the outer zones 17g, 18d, 20g, 21d and 21g coextensive with the pupil of the respective eye during periods of low illumination covers at least approximately two-thirds of the respective pupil.

Fig. 24 illustrates a pair of multifocal corneal contact lenses 24a and 24b, wherein the first lens 24a includes an upper D-shaped intermediate distance correction zone 24c separated from a lower, D-shaped near vision correction zone 24d by a strip-shaped distant vision correction zone 24e. The other lens 24b includes an upper, D-shaped near vision correction zone 24f disposed on a side of a strip-shaped, centrally located distant vision correction zone 24h opposite a lower, D-shaped intermediate distance correction zone 24g.

As shown in Fig. 25, a pair of multifocal corneal contact lenses 25a and 25b includes a first contact lens 25a with a pair of D-shaped correction zones 25c and 25d at the top and bottom of the lens, separated by a strip-shaped auxiliary correction zone 17e. D-shaped zones 25c and 25d are a distant vision correction zone and an intermediate distance correction zone, respectively, while middle zone 25e constitutes a near vision correction zone. The second contact lens 25b of the pair shown in Fig. 25 comprises a strip-shaped near vision correction zone 25h sandwiched between an upper, D-shaped intermediate distance correction zone 25f and a lower, D-shaped distant vision correction zone 25g.

In a pair of multifocal corneal contact lenses 26a and 26b depicted in Fig. 26, a first lens 26a comprises an upper, D-shaped distant vision correction zone 26c separated by a strip-shaped intermediate distance correction zone 26e from a lower, D-shaped near vision correction zone 26d. A second lens 26b includes an upper, D-shaped distant vision correction zone 26f and a lower, D-shaped intermediate distance corr ction zone 26g disposed n opposite sides of a central, strip-shaped near vision c rrection zone 26h.

A first contact lens 27a of pair of multifocal corneal contact lenses 27a and 27b illustrated in Fig. 27 includes three vertically superimposed zones: (a) an upper, intermediate distance correction zone 27c, (b) a middle, distant vision correction zone 27e and (c) a lower, near vision correction zone 27d. The other lens 27b of the pair shown in Fig. 27 comprises a first D-shaped correction zone 27f, a second D-shaped correction zone 27g and a substantially strip-shaped correction zone 27h separating the two D-shaped zones 27f and 27g. Zones 27f, 27g and 27h are an intermediate distance correction zone, a distant vision correction zone and a near vision correction zone, respectively.

Fig. 28 illustrates a pair of multifocal corneal contact lenses 28a and 28b, wherein the first lens 28a includes an upper D-shaped near vision correction zone 28c separated from a lower, D-shaped distant vision correction zone 28d by a strip-shaped intermediate distance correction zone 28e. The other lens 28b includes an upper, D-shaped near vision correction zone 28f disposed on a side of a strip-shaped, centrally located distant vision correction zone 28h opposite a lower, D-shaped intermediate distance correction zone 28g.

As shown in Fig. 29, a pair of multifocal corneal contact lenses 29a and 29b includes a first contact lens 29a with a pair of D-shaped correction zones 29c and 29d at the top and bottom of the lens, separated by a strip-shaped auxiliary correction zone 18e. D-shaped zones 29c and 29d ar a distant vision correction zone and a near vision correction zone, respectively, while middle zone 29e constitutes an intermediate distance correction zone. The second contact lens 29b of the pair shown in Fig. 29 comprises a strip-shaped distant vision correction zone 29h sandwiched between an upper, D-shaped intermediate distance correction zone 29f and a lower, D-shaped near vision correction zone 29g.

In a pair of multifocal corneal contact lenses 30a and 30b depicted in Fig. 30, a first lens 30a comprises an upper, D-shaped near vision c rrecti n zone 30c separated by a strip-shaped intermediate distance c rrection zone 30e from a lower, D-shaped distant vision correction zone 30d. A second

lens 30b includes an upper, D-shaped intermediate distance correction zone 30f and a lower, D-shaped distant vision correction zone 30g disposed on opposite sides of a central, strip-shaped near vision correction zone 30h.

A first contact lens 31a of pair of multifocal corneal contact lenses 31a and 31b illustrated in Fig. 31 includes three vertically superimposed zones: (a) an upper, distant vision correction zone 31c, (b) a middle, near vision correction zone 31e and (c) a lower, intermediate distance correction zone 31d. The other lens 31b of the pair shown in Fig. 31 comprises a first D-shaped correction zone 31f, a second D-shaped correction zone 31g and a substantially strip-shaped correction zone 31h separating the two D-shaped zones 31f and 31g. Zones 31f, 31g and 31h are a near vision correction zone, an intermediate distance correction zone, and a distant vision correction zone, respectively.

As shown in Fig. 32, a first lens 32a of a pair of multifocal corneal contact lenses 32a and 32b includes an upper, substantially D-shaped correction zone 32c and a lower, substantially D-shaped correction zone 32d together surrounding a circular centrally disposed correction zone 32e. Zones 32c, 32d and 32e are an intermediate distance correction zone, a near vision correction zone and a distant vision correction zone, respectively. The second lens 32b of the pair shown in Fig. 32 includes an upper, D-shaped intermediate distance correction zone 32f and a lower, D-shaped distant vision correction zone 32g disposed on opposite sides of a strip-shaped near vision correction zone 32h.

A first lens 33a of a pair of multifocal corneal contact lenses 33a and 33b illustrated in Fig. 33 includes an upper, substantially D-shaped correction zone 33c and a lower, substantially D-shaped correction zone 33d together surrounding a circular centrally disposed correction zone 33e. Zones 33c, 33d and 33e are a distant vision correction zone, a near vision correction zone and an intermediate distance correcti n zone, respectively. The second lens 33b of the pair shown in Fig. 33 includes an upper, D-shaped near vision correction zone 33f and a lower, D-shaped distant vision correction zone 33g disposed on opposite sides of a strip-shaped intermediate

distance correction zone 33h.

As shown in Fig. 34, a first lens 34a of a pair of multifocal corneal contact lenses 34a and 34b includes an upper, substantially D-shaped correction zone 34c and a lower, substantially D-shaped correction zone 34d together surrounding a circular centrally disposed correction zone 34e. Zones 34c, 34d and 34e are an intermediate distance correction zone, a near vision correction zone and a distant vision correction zone, respectively. Second lens 34b includes three correction zones 34f, 34g and 34h arranged concentrically with respect to one another. Circular center zone 34f is a near vision correction zone, whereas outer zone 34g is a distant vision correction zone and middle zone 34h is an intermediate distance correction zone.

A first lens 35a of a pair of multifocal corneal contact lenses 35a and 35b illustrated in Fig. 35 includes an upper, substantially D-shaped correction zone 35c and a lower, substantially D-shaped correction zone 35d together surrounding a circular centrally disposed correction zone 35e. Zones 35c, 35d and 35e are a distant vision correction zone, a near vision correction zone and an intermediate distance correction zone, respectively. The second lens 35b of the pair shown in Fig. 35 includes three correction zones 35f, 35g and 35h arranged concentrically with respect to one another. Circular center zone 35f is an intermediate distance correction zone, whereas outer zone 35g is a distant vision correction zone and middle zone 35h is a near vision correction zone.

A first lens 36a of a pair of multifocal corneal contact lenses 36a and 36b illustrated in Fig. 36 includes an upper, substantially D-shaped near vision correction zone 36c and a lower, substantially D-shaped distant vision correction zone 36d together surrounding a circular centrally disposed intermediate distance correction zone 36e. The second lens 36b of the pair shown in Fig. 36 includes three correction zones 36f, 36g and 36h arranged concentrically with respect to one another. Circular center zone 36f is a near vision correction zone, whereas outer zone 36g is a distant vision correction zone and middle zone 36h is an intermediate distance correcti n zone.

The contact lenses of the instant invention can be made of any conventional contact lens material. Such materials are polymeric compositions including, but not limited to, soft lens and hard lens materials, gas permeable polymers, and, more particularly, ethyl methacrylates and silicone acrylates.

The contact lenses of the instant invention may be manufactured by machining. In particular, the lenses with a point symmetric or concentric configuration may be produced by cutting on a lens lathe, as described in U.S. Patent No. 4,704,016 to de Carle. Pursuant to the disclosure of that patent, the anterior or convex side of the lens (facing away from the eye surface) is initially cut along a curve essentially matching the final surface of the distant vision correction zone or zones of the lens. The near vision correction zones are then machined by taking a series of steeper cuts. Sharp steps may be avoided by continually changing the position of the center of curvature when moving the cutting tool in a controlled maner to produce the desired profile.

Accordingly, intermediate-distant, intermediate distance, and intermediate-near vision correction zones are produceable by taking a first series of cuts for the intermediate-distant zones, a second series of deeper cuts for the intermediate distance zones and a third series of even deeper cuts for the near vision zones.

Pursuant to the teachings of de Carle, the different correction zones of a contact lens in accordance with the instant invention may alternatively or additionally be implemented by embedding, in a base matrix, pieces of material having a refractive index different from that of the base material.

The contact lenses of the instant invention are manufactured preferably by a molding technique, optionally with subsequent machining and polishing, to form recesses on the posterior (cornea facing) sides of the lenses for producing the various correction zones.

As illustrated in Fig. 37, 1 ns 1a of Fig. 1 is provid d on a posterior side 37a with an annular peripheral cornea matching surface 37b, an annular concave surface 37c

corresponding to annular near vision correction zone 1d, and a centrally located concave surface 37d corresponding to circular distant vision correction zone 1c. Concave surface 37d has a radius of curvature which is smaller than the radius of curvature of annular concave surface 37c which in turn is smaller than the radius or radiii of curvature of the cornea matching surface(s) 37b. Concave surface 37c is preferably also a cornea matching surface, the prescription of near vision correction zone 1d being controlled in that event by the curvature of an outer, convex surface 37e of lens 1a. The radii of curvature of concave surface 37d is predetermined so that, together with a tear reservoir which will be formed between the lens and the eye surface upon application of the lens to the eye, the particular prescription of a patient is satisfied.

Alternatively, the recess formed by concave surface 37d may be filled with an appropriate gas permeable synthetic resin material. In that case, the radii of curvature of concave surface 37d is modified to achieve the same prescription.

Similarly, as depicted in Fig. 38, lens 1b is provided on a posterior side 38a with an annular peripheral cornea matching surface or surfaces 38b, an annular concave surface 38c for forming distant vision correction zone 1f, and a central circular concave surface 38d for forming near vision correction zone 1e. The radius of curvature of concave surface 38c is predetermined so that, together with a tear reservoir which will be formed between the lens surface and the eye surface upon application of the lens to the eye, the particular distant vision prescription of a patient is satisfied. Alternatively, the recess formed by concave surface 38c may be filled with an appropriate gas permeable synthetic resin material. If so, the radii of curvature of that concave surface is modified to result in the same prescription. Concave surface 38d may be a conrean matching surface and thus have a radius of curvature predetermined by the curvature of the patient's cornea at the center of the respective eye. In that case, the patient's near vision prescription for that eye is attained by controlling the curvature of anterior lens surface 38e.

Fig. 39 shows a cross-sectional configuration of lens 2a. A posterior side 39a of lens 2a includes an annular peripheral cornea matching surface 39b having a relatively large radius of curvature, an annular concave surface 39c also having a relatively large radius of curvature, an intermediate annular concave surface 39d having a relatively small radius of curvature, and a centrally located circular concave surface 39e having an even smaller radius of curvature. Surfaces 39c, 39d and 39e correspond to near vision correction zone 2d, intermediate distance correction zone 2e and distant vision correction zone 2c, respectively. As described hereinabove with reference to lenses 1a and 1b, surface 39c is preferably a cornea matching surface, while the radii of curvature of surfaces 39d and 39e are determined in part by whether the recesses formed by the surfaces are filled with a polymeric material (e.g., gas permeable silicone acrylate) or tear fluid.

As shown in Fig. 40, lens 2b is provided on a posterior side 40a with an annular peripheral cornea matching surface 40b, an annular concave surface 40c, another annular concave surface 40d and a central circular concave surface 40e. Surfaces 40c, 40d, and 40e correspond to distant vision correction zone 2g, intermediate distance correction zone 2h and near vision correction zone 2f, respectively. The radius of curvature of distant vision surface 40c is smaller than the radius of curvature of intermediate distance surface 40d which in turn is smaller than the radius of curvature of near vision surface 40e. Surface 40e may contact (via an intermediate tear layer) the cornea of the respective eye, while surfaces 40c and 40d are spaced from the cornea by a tear reservoir, formed upon application of the respective contact lens to the patient's eye, or by a polymeric, preferably gas permeable material. The precise curvatures of the concave surfaces 40c and 40d will vary in accordance with whether the intervening polymeric layer is included.

As depicted in Fig. 41, contact lens 8a may be provided on a posterior side 41a with an annular peripheral cornea matching surface 41b, an upper concave surface 41c, a middle concave surface 41d and a lower concave surface 41e.

Surfaces 41c, 41d and 41e respectively correspond to distant vision correction zone 8c, intermediate distance correction zone 8e and near vision correction zone 8d. Distant vision surface 41c has a radius of curvature smaller than the radius of curvature of intermediate distance surface 41d which is in turn smaller than the radius of curvature of lens surface 41e.

Fig. 42 illustrates a cross-sectional view of lens 15b. On a posterior side 42a, lens 15b is formed with an annular cornea matching surface 42b, an upper concave surface 42c, a centrally located circular concave surface 42d and a lower concave surface 42e. Surfaces 42c, 42d and 42e form intermediate distance correction zone 15f, near vision correction zone 15h and distant vision correction zone 15g, respectively. Upper and lower surfaces 42c and 42e extend horizontally across the lens and have radii of curvature smaller than the radius of curvature of surface 42d. The radius of curvature of surface 42e is smaller than the radius of curvature of surface 42c.

Drawing figures 43 through 67 illustrate pairs of corneal contact lenses with members having multiple correction zones which differ in configuration from one to the other to provide a modified monovision correction for presbyopia. One member of each pair is intended for one eye of a patient, while the other member is intended for the other eye.

Figs. 43 through 52 all illustrate multifocal contact lenses wherein one lens has two distant vision correction zones of essentially the same focal length separated by another, auxiliary correction zone of a different focal length. The other contact lens has two near vision correction zones of essentially a common focal length separated by another, auxiliary correction zone of a focal length different from the common focal length of the two near vision correcti n zones.

It is to be noted that, for purposes of simplifying the drawing, the plan views of Figs. 43 through 56 and 61 through 67 have omitted a representation of an annular peripheral cornea matching zone included in each lens pursuant to conventional lens design. These corneal matching areas are shown in the cross-sectional views of Figs. 57 through 60.

Fig. 43 shows a distant vision contact lens 43a and a near vision contact lens 43b. Lens 43a has a circular distant vision (D) correction zone 43c preferably, but not necessarily, located at the geometric center of the lens and an annular distant vision correction zone 43d at the outer periphery of the lens. Distant vision correction zones 43c and 43d have the same focal length and are separated by a near vision (N) correction zone 43e. Lens 43b has a circular, innermost near vision correction zone 43f and an annular, outermost near vision correction zone 43g of a common focal length, separated by a distant vision correction zone 43h.

Fig. 44 also shows a distant vision contact lens 44a and a near vision contact lens 44b. Lens 44a has a circular distant vision correction zone 44c preferably, but not necessarily, located at the geometric center of the lens and an annular distant vision correction zone 44d at the outer periphery of the lens. Distant vision correction zones 44c and 44d have the same focal length and are separated by an intermediate distance correction zone 44e. The other lens 44b has a circular, innermost near vision correction zone 44f and an annular, outermost near vision correction zone 44g of a common focal length, separated by an auxiliary correction zone in the form of an annular intermediate distance correction zone 44h.

As depicted in Fig. 45, a first contact lens 45a includes a circular innermost correction zone 45c and an annular outer correction zone 45d separated by an annular auxiliary correction zone 45e. Correction zones 45c and 45d are distant vision correction zones, while middle zone 45e is an intermediate-distant vision (ID) correction zone with a focal length which would be longer than the focal length of an intermediate distance correction zone 44e (Fig. 44) for the same eye of the same patient. Accordingly, the focal length of intermediate-distant correction zone 45e can be considered closer to the focal length of zones 45c and 45d than the focal length of intermediate distance correction zone 44e is to the focal length of zones 44c and 44d.

The other contact lens 45b of the pair of Fig. 45 includ s a circular innermost correction zone 45f and an

annular outer correction zone 45g separated by an annular auxiliary correction zone 45h. Correction zones 45f and 45g are near vision correction zones, while middle zone 45h is an intermediate-near vision (IN) correction zone with a focal length which would be shorter than the focal length of an intermediate distance correction zone 44h (Fig. 44) for the same eye of the same patient. Thus, the focal length of intermediate-near vision correction zone 45h is generally closer to the focal length of zones 45f and 45g than the focal length of intermediate distance correction zone 44h is to the focal length of zones 44f and 44g.

Preferably, the inner, circular correction zones 43c, 43f, 44c, 44f and 45c, 45f of the lenses shown in Figs. 43 through 45 each have an area equal to approximately two-thirds of a minimum area subtended by the respective pupil of the patient. This area distribution is believed to optimally minimize blurring during periods of high illumination.

During periods of low illumination (e.g., night driving) , visual acuity in distant vision contact lens 43a, 44a or 45a is ensurable, provided that the respective inner distant vision correction zone 43c, 44c or 45c of each lens 43a, 44a or 45a and a portion of the respective outer distant vision correction zone 43d, 44d or 45d coextensive with the pupil of the respective eye in a maximally opened state of such pupil together cover an area equal approximately to at least two-thirds of the area subtended by the pupil in the maximally opened state. Similarly, visual acuity may be maximized in the near vision contact lenses 43b, 44b and 45b, provided that the respective inner near vision correction zone 43f, 44f or 45f and a portion of the respective outer near vision correction zone 43g, 44g or 45g coextensive with the pupil of the respective eye in a maximally opened state of such pupil together also covers an area equal approximately to at least two-thirds of a maximum area subtended by the respective pupil in its maximally opened state.

It is to be noted that each distant vision contact lens 43a, 44a and 45a may be viewed as having a single distant vision correction zone interrupted by a narrow annular auxiliary correction zone 43e, 44e r 45e. Similarly, each

near vision contact lens 43b, 44b and 45b may be viewed as having a single near vision correction zone interrupted by a narrow annular auxiliary correction zone 43h, 44h or 45h. The center circular zone of each lens 43a, 44a, 45a, 43b, 44b and 45b may have a diameter (in plan view of the respective lens) between 6 and 8 millimeters, an annular middle correction zone 43e, 44e, 45e, 43h, 44h or 45h approximately three-quarters of a millimeter in width, and an annular outer correction zone 43d, 44d, 45d, 43g, 44g or 45g on the order of two millimeters in width. In addition, each contact lens has an annular outer periphery or skirt (not illustrated in any of the plan views, but see Figs. 57 through 60) having no corrective function, but serving to seat the respective lens on the corneal surface.

As illustrated in Fig. 46, one contact lens 46a has a circular innermost correction zone 46c separated from an annular outermost correction zone 46d by three annular middle correction zones 46e, 46f and 46g. Innermost and outermost zones 46c and 46d are distant vision correction zones, while annular middle zones 46e and 46g are intermediate-distant vision correction zones and middle zone 46f is a true intermediate distance correction zone. Thus, the focal length of middle zone 46f is generally shorter than the focal length of middle zones 46e and 46g.

Similarly, second contact lens 46b of the pair shown in Fig. 46 has a circular innermost correction zone 46h separated from an annular outermost correction zone 46i by three annular middle correction zones 46j, 46k and 46m. Innermost and outermost zones 46h and 46i are near vision correction zones, while annular middle zones 46j and 46m are intermediate-near vision correction zones and middle zone 46k is a true intermediate distance correction zone, the focal length of middle zone 46k being longer than the focal length of middle zones 46j and 46m.

Intermediate-distant vision correction zones 46e and 46g of contact lens 46a have a first common focal length, and intermediate-near vision correction zones 46j and 46m of contact lens 46b have a second common focal length. Preferably, the middle correction zon s 46e, 46f, 46g, 46j, 46k and 46m

have a radial dimension or width substantially thinner than the radial dimension of outer correction zones 46d and 46i or the radii of inner correction zones 46c and 46h. The magnitudes of the focal lengths of intermediate distance correction zones 46f and 46k depend, like the focal lengths of the other zones of the two contact lenses, on the prescription requirements of the individual patient. Thus, the focal lengths of the various distance correction zones, for example, the intermediate distance correction zones or the distant vision correction zones, will be the same for the two eyes only if the eyes require the same focal correction in the intermediate and long distance ranges.

As illustrated in Fig. 47, one contact lens 47a has a circular innermost correction zone 47c separated from an annular outermost correction zone 47d by three annular middle correction zones 47e, 47f and 47g. Innermost and outermost zones 47c and 47d are distant vision correction zones, while annular middle zones 47e and 47g are intermediate distance correction zones and middle zone 47f is a near vision correction zone.

Similarly, second contact lens 47b of the pair shown in Fig. 47 has a circular innermost correction zone 47h separated from an annular outermost correction zone 47i by three annular middle correction zones 47j, 47k and 47m. Innermost and outermost zones 47h and 47i are near vision correction zones, while annular middle zones 47j and 47m are intermediate distance correction zones and middle zone 47k is a distant vision correction zone. The focal length of middle zone 47k may or may not be substantially equal to the focal length of distant vision correction zones 47c and 47d of lens 47a, depending on the corrections required for the patient's eyes.

Generally, intermediate distance correction zones 47e and 47g have a first common focal length, intermediate distance correction zone 47j and 47m have a second common focal length, distant vision correction zones 47c and 47d have a third common focal length, and near vision correction zones 47h and 47i have a fourth common focal length. In addition, near vision correction zones 47f and 47k have their wn respective focal lengths. Preferably, to minimize blurring

and therefore optimize visual acuity, the middle correction zones 47e, 47f, 47g, 47j, 47k and 47m have a radial dimension or width substantially thinner than the radial dimension of outer correction zones 47d and 47i or the radii of inner correction zones 47c and 47h.

As depicted in Fig. 48, another pair of contact lenses includes a first lens 48a with two D-shaped distant vision correction zones 48c and 48d separated by a strip-shaped near vision correction zone 48e. A second lens 48b comprises two D-shaped near vision correction zones 48f and 48g separated by a strip-shaped distant vision correction zone 48h.

As shown in Fig. 49, yet another pair of contact lenses includes a first lens 49a with two D-shaped distant vision correction zones 49c and 49d separated by a strip-shaped intermediate distance correction zone 49e. A second lens 49b comprises two D-shaped near vision correction zones 49f and 49g separated by a strip-shaped intermediate distance correction zone 49h. Distant vision correction zones 49c and 49d have a common focal length and near vision correction zones 49f and 49g also have a common focal length.

Fig. 50 illustrates two contact lenses 50a and 50b having D-shaped distant vision correction zones 50c and 50d, D-shaped near vision correction zones 50f and 50g, a strip-shaped intermediate-distant vision correction zone 50e between D-shaped zones 50c and 50d, and a strip-shaped intermediate-near vision correction zone 50h between D-shaped zones 50f and 50g. As described hereinabove, the focal lengths of intermediate-distant vision correction zone 50e and intermediate-near vision correction zone 50h are respectively longer and shorter than the focal length of a true intermediate distance correction zone would be and accordingly are closer in value to the focal lengths of distant vision correction zones 50c and 50d and near vision correction zones 50f and 50g, respectively.

Fig. 51 is an illustration of a first contact lens 51a having two substantially D-shap d correction zones 51c and 51d and three substantially strip-shaped c rrection zones 51e, 51f and 51g between D-shaped zones 51c and 51d. A second con-

tact lens of the pair includes two substantially D-shaped c rrection zones 51h and 51i and three substantially strip-shaped correction zones 51j, 51k and 51m between D-shaped zones 51h and 51i.

Zones 51e and 51g are intermediate-distant vision correction zones, while zones 51j and 51m are intermediate-near vision correction zones. Middle zones 51f and 51k are intermediate distance correction zones. Middle zone 51f has a focal length less in value than a focal length of intermediate-distant vision correction zones 51e and 51g, while middle zone 51k has a focal length greater in value than a common focal length of intermediate-near vision correction zones 51j and 51m. Accordingly, the preferably identical focal lengths of intermediate-distant vision correction zones 51e and 51g are closer in value than the focal length of intermediate distance correction zone 51f to the preferably common focal lengths of distant vision correction zones 51c and 51d. Similarly, the preferably identical focal lengths of intermediate-near vision correction zones 51j and 51m are closer in value than the focal length of intermediate distance correction zone 51k to the preferably common focal lengths f near vision correction zones 51h and 51i.

Fig. 52 shows a corneal contact lens pair including a first lens 52a having two substantially D-shaped correction zones 52c and 52d and three substantially strip-shaped correction zones 52e, 52f and 52g between D-shaped zones 52c and 52d. A second lens of the pair includes two substantially D-shaped correction zones 52h and 52i and three substantially strip-shaped correction zones 52j, 52k and 52m between D-shaped zones 52h and 52i.

Zones 52e and 52g are all intermediate distance correction zones having the same focal length. Likewise, zones 52j and 52m are intermediate distance correction zones having a common focal length. Middle zones 52f and 52k constitute a near vision correction zone and a distant vision correction zone, respectively.

As depicted in Fig. 53, a first contact lens 53a of a pair of multifocal corneal contact lenses includes three correction zones 53c, 53d and 53e arranged in a concentric

configuration. Innermost correction zone 53c is a circular distant vision correction zone, while outer zone 53d is an annular distant vision correction zone. Zone 53e is an annular intermediate distance correction zone separating the two distant vision correction zones 53c and 53d. The second contact lens 53b of the pair shown in Fig. 53 includes two D-shaped correction zones 53f and 53g flanking a substantially strip-shaped middle correction zone 53h. D-shaped zones 53f and 53g are near vision correction zones, while middle zone 53h is an intermediate distance correction zone. Zones 53e and 53h have essentially respective focal lengths which may be more or less equal to one another, depending on the prescriptions of a patient's eyes. Distant vision correction zones 53c and 53d have a common focal length larger in value than the focal length of intermediate distance correction zone 53e. Likewise, near vision correction zones 53f and 53g have the same focal length which is less than the focal length of intermediate distance correction zone 53h.

As depicted in Fig. 54, a first contact lens 54a of a pair of multifocal corneal contact lenses includes two D-shaped correction zones 54c and 54d flanking a substantially strip-shaped middle correction zone 54e. D-shaped zones 54c and 54d are distant vision correction zones, while middle zone 54e is a near vision correction zone. Preferably, zones 54c and 54d have essentially the same focal length.

The second contact lens 54b of the pair shown in Fig. 54 includes three correction zones 54f, 54g and 54h arranged in a concentric configuration. Innermost correction zone 54f is a circular near vision correction zone, while outer zone 54h is an annular near vision correction zone. Zone 54g is an annular distant vision correction zone separating the two near vision correction zones 54f and 54h.

Fig. 55 is a rendering of a pair of multifocal corneal contact lenses 55a and 55b identical to lens 44a and 61a, respectively. Accordingly, lens 55a has a circular distant vision correction zone 55c preferably, but not necessarily, located at the geometric cent r of the lens and an annular distant vision correcti n zone 55d at the outer periphery of the lens. Distant vision correction zon s 55c

and 55d have the same focal length and are separated by an intermediate distance correction zone 55e. In addition, lens 55b has a D-shaped distant vision correction zone 55f disposed above a D-shaped near vision correction zone 27g.

Fig. 56 shows a distant vision contact lens 56a and a near vision contact lens 56b. Lens 56a has a circular distant vision correction zone 56c preferably, but not necessarily, located at the geometric center of the lens and an annular distant vision correction zone 56d at the outer periphery of the lens. Distant vision correction zones 56c and 56d have the same focal length and are separated by an intermediate distance correction zone 56e. The other lens 56b includes a pair of D-shaped correction zones 56f and 56g. Upper zone 56f is an intermediate distance correction zone, while lower correction zone 56g is a near vision correction zone.

The contact lenses of the instant invention can be made of any conventional contact lens material. Such materials are polymeric compositions including, but not limited to, soft lens and hard lens materials, gas permeable polymers, and, more particularly, ethyl methacrylates and silicone acrylates.

The contact lenses of the instant invention are manufactured preferably by a molding technique, optionally with subsequent machining and polishing, to form recesses on the posterior (cornea facing) sides of the lenses for producing the various correction zones.

As illustrated in Fig. 57, lens 44a of Fig. 44 may be provided on a posterior side 57a with an annular cornea matching peripheral surface 57b, a first annular concave surface 57c, a second annular concave surface 57d, and a substantially hemispherical or circular concave surface 57e. Surfaces 57c, 57d and 57e correspond to distant vision correction zone 44d, intermediate distance correction zone 44e and distant vision correction zone 44c of lens 44a, respectively. The radii of curvature of surfaces 57c and 57e are essentially equal, while the radius of curvature of middle concave surface 57d is greater than the radius of curvature of surfaces 57c and 57e. The radii f curvature of the vision correction zone

surfaces 57c, 57d and 57e are all less than the radius (or radii) of curvature of cornea matching surface(s) 57b. The radii of curvature are predetermined so that, together with a tear reservoir which will be formed between the lens and the eye surface upon application of the lens to the eye, the particular prescription of a patient is satisfied.

Alternatively, the recess defined by concave surfaces 57c, 57d and 57e may be filled with an appropriate gas permeable synthetic resin material. In that case, the radii of curvature of the surfaces 57c, 57d and 57e is modified to achieve the same prescription.

Similarly, as depicted in Fig. 58, lens 44b may be provided on a posterior side 58a with an annular cornea matching peripheral surface 58b, an annular concave surface 58c and a circular, inner concave surface 58d. Surface 58c corresponds to intermediate distance correction zone 44h (Fig. 44) and has a radius of curvature which is smaller than the radius of curvature of inner concave surface 58d, which corresponds to near vision correction zone 44c, and smaller than the radius of curvature of cornea matching surface 58b.

As shown in Fig. 59, lens 4a may be provided on a posterior side 59a with an annular cornea matching peripheral surface 59b, a first annular concave surface 59c, a second annular concave surface 59d, a third annular concave surface 59e, a fourth annular concave surface 59f and a circular, inner concave surface 59g. Surfaces 59c, 59d, 59e, 59f and 59g respectively correspond to distant vision correction zone 46d, intermediate-distant vision correction zone 46g, intermediate distance correction zone 46f, intermediate-distant vision correction zone 46e and distant vision correction zon 46c of lens 46a. Surfaces 59c and 59g have a common radius of curvature smaller than a common radius of curvature of surfaces 59d and 59f, which in turn is smaller than a radius of curvature defining surface 59e. The radii of curvature of all the correction zone surfaces 59c through 59g are smaller than the radii of curvature of cornea matching surface(s) 59b. As s t f rth hereinab ve, the radii of curvatur of surfaces 59c through 59g will change if th recess defined by the surfaces is filled with one or several gas permeable synthetic

resin materials.

As shown in Fig. 60, contact lens 46b may be provided on a posterior side 60a with an annular cornea matching peripheral surface 60b, a first annular concave surface 60c, a second annular concave surface 60d, a third annular concav surface 60e, and a circular, inner concave surface 60f. Surfaces 60c, 60d, 60e and 60f correspond to intermediate-near vision correction zone 46m, intermediate distance correction zone 46k, intermediate-near vision correction zone 46j and near vision correction zone 46h, respectively. Surfaces 60c and 60e have a common radius of curvature larger than a radius of curvature of surface 60d and smaller than a radius of curvature of surface 60f. The radius of curvature of surface 60f equals the radius of curvature of an inner annular portion of cornea matching surface 60b which corresponds to near vision correction zone 46i. The radii of curvature of surfaces 60c through 60f will change if the recess defined by the surfaces is filled with one or several gas permeable synthetic resin materials.

As illustrated in Fig. 61, a pair of monovision type corneal contact lenses including a distant vision contact lens 61a and a near vision contact lens 61b in accordance with the present invention may be provided with respective circular arrays 61c and 61d of small circular correction zones 61e and 61f having one or more focal lengths different from a characteristic focal length of the major portion of the respective lens. For example, circular zones 61e and 61f may all constitute intermediate distance correction zones having a comm n focal length. Alternatively, circular zones 61e of lens 61a may be intermediate-distant vision correction zones, while circular correction zones 61f may be near vision correction zones. In accordance with yet another alternative, only some of the small circular zones of each lens may be intermediate distance correction zones. In that case, the other small circular zones in lens 61a may be near vision correction zones or intermediate-distant vision correction zones, while the other small circular zones in lens 61b may be distant visi n correction zones or intermediate-near vision correction zones.

A pair of mon vision type corneal contact lenses,

illustrated in Fig. 62, including a distant vision contact lens 62a and a near vision contact lens 62b in accordance with the present invention may be provided with respective circular arrays 62c and 62d of small triangular correction zones 62e and 62f having one or more focal lengths different from a characteristic focal length of the major portion of the respective lens. For example, triangular zones 62e and 62f may all constitute intermediate distance correction zones having a common focal length. Alternatively, triangular zones 62e of lens 62a may be intermediate-distant vision correction zones, while triangular correction zones 62f may be near vision correction zones. If only some of the small triangular zones of each lens are intermediate distance correction zon s, the other small triangular zones in lens 62a may be near vision correction zones or intermediate-distant vision correction zones, while the other small triangular zones in lens 62b may be distant vision correction zones or intermediate-near vision correction zones.

Fig. 63 depicts a distant vision contact lens 63a and a near vision contact lens 63b in accordance with the present invention. Lenses 63a and 63b may be provided with respective substantially circular arrays 63c and 63d of small crescent-shaped correction zones 63e and 63f having one or more focal lengths different from a characteristic focal length of the major portion of the respective lens. For example, crescent-shaped zones 63e and 63f may all constitute intermediate distance correction zones having a common focal length. Alternatively, crescent-shaped zones 63e of lens 63a may be intermediate-distant vision correction zones, while crescent-shaped correction zones 63f may be near vision correction zones. In accordance with yet another alternative, only some of the small crescent-shaped zones of each lens may be intermediate distance correction zones. In that case, the other small crescent-shaped zones in lens 63a may be near vision correction zones or intermediate-distant vision correction zones, while the other small crescent-shaped zones in lens 63b may be distant vision correction zones or intermediate-near vision correction zones.

As shown in Fig. 64, a distant vision lens 64a of a

pair of monovision corneal contact lenses includes a major portion 64c with a distant vision corrective focal length, and a narrow, horizontally oriented correction zone 64d of a focal length different from the focal length of the major portion of the lens. A second lens 64b has a major portion 64e of a near vision focal length. The near vision lens is further provided with a narrow strip-shaped correction zone 64f oriented horizontally and having a focal length different from the focal length of the major portion of the near vision lens. Both strip-shaped auxiliary correction zones 64d and 64f are disposed above a horizontal center line of the respective lenses. Alternatively, both could be disposed below the center line. Correction zones 64d and 64f may both be intermediate distance correction zones. Or zone 64d may be an intermediate-distant vision correction zone or a near vision correction zone. Similarly, zone 64f could be an intermediate-near vision correction zone or a distant vision correction zone.

Fig. 65 shows another pair of monovision type corneal contact lenses. A distant vision contact lens 65a is identical to lens 65a and thus includes a major portion 65c with a distant vision corrective focal length, and a narrow, horizontally oriented correction zone 65d of a focal length different from the focal length of the major portion of the lens. A near vision lens 65b has a major portion 65e of a near vision focal length. The near vision lens is further provided with a narrow strip-shaped correction zone 65f oriented horizontally and having a focal length different from the focal length of the major portion of the near vision lens. Strip-shaped auxiliary correction zone 65d is disposed above a horizontal center line of the respective lens 65a, while strip-shaped zone 65f is disposed below the horizontal axis of symmetry of lens 65b. Correction zones 65d and 65f may both be intermediate distance correction zones. Or zone 65d may be an intermediate-distant vision correction zone or a near vision correction zone. Similarly, zone 65f could be an intermediate-near vision correction zone or a distant vision correction zone.

Fig. 66 illustrates yet another pair f mon vision

type corneal contact lenses. A distant vision contact lens 66a includes a major portion 66c with a distant vision corrective focal length, and a thin, crescent-shaped substantially horizontally oriented correction zone 66d of a focal length different from the focal length of the major portion of the lens. A near vision lens 66b has a major portion 66e of a near vision focal length. The near vision lens is further provided with a thin crescent-shaped correction zone 66f oriented horizontally and having a focal length different from the focal length of the major portion of the near vision lens. Auxiliary correction zone 66d is disposed above a horizontal center line of the respective lens 66a, while zone 66f is disposed below the horizontal axis of symmetry of lens 66b. Correction zones 66d and 66f may both be intermediate distance correction zones. Or zone 66d may be an intermediate-distant vision correction zone or a near vision correction zone. Similarly, zone 66f could be an intermediate-near vision correction zone or a distant vision correction zone.

Fig. 67 shows two monovision lenses 67a and 67b with major correction zones 67c and 67e, respectively, and crescent-shaped auxiliary correction zones 67d and 67f having locations, sizes and orientations similar to the locations, sizes and orientations of zones 64d and 64f in Fig. 64.

It is to be noted that the essential feature of all the monovision lenses illustrated in Figs. 61 through 67 and of other generally monovision type correction lenses described herein is that the portion of the principal correction zone or zones (either distant vision or near vision correction) coextensive with the pupil of the respective eye covers more than approximately two-thirds (more preferably seventy-five percent and most preferably eighty percent) of the area of the pupil. The concomitant upper limit (33%, 25%, 20%) on the pupil area covered by the auxiliary zones is satisfied regardless of the disposition of the respective contact lens on the eye and regardless of the size of the respective pupil. This proportionate coverage of the pupil minimizes blurring, while enabling auxiliary vision correction (usually intermediate) in ach substantially monovision contact lens.

Although the invention has been described in terms

of particular embodiments and applications, one of ordinary skill in the art, in light of this teaching, can generate additional embodiments and modifications without departing from the spirit of or exceeding the scope of the claimed invention. Accordingly, it is to be understood that the drawings and descriptions herein are proferred by way of example to facilitate comprehension of the invention and should not be construed to limit the scope thereof.

CLAIMS:

1. A pair of corneal contact lenses, comprising:

a first contact lens for one eye of a patient, said lens having a first distant vision correction zone and a second distant vision correction zone separated from one another by a first auxiliary correction zone, said first distant correction zone and said second distant vision correction zone having a first common focal length, said auxiliary correction zone having a first additional focal length different from said common focal length; and

a second contact lens for the other eye of the patient, said second contact lens having a first near vision correction zone and a second near vision correction zone separated from one another by a second auxiliary correction zone, said first distant correction zone and said second distant vision correction zone having a second common focal length, said second auxiliary correction zone having a second additional focal length different from said second common focal length.

2. The pair of contact lenses defined in claim 1 wherein said first auxiliary correction zone and said second auxiliary correction zone are intermediate distance correction zones.

3. The pair of contact lenses defined in claim 1 wherein said first distant vision correction zone, said second distant vision correction zone and said first auxiliary correction zone are concentric with each other and wherein said first near vision correction zone, said second near vision correction zone and said second auxiliary correction zone are concentric with each other.

4. The pair of contact lenses defined in claim 1 wherein said first distant vision correction zone, said second distant vision correction zone, said first near vision correction zone and said s c nd near vision c rr cti n zone are all essentially D-shaped in plan view f said first contact lens and said second contact lens, respectively, said first

auxiliary correction zone and said second auxiliary correction zone being essentially strip shaped in plan view of said first contact lens and said second contact lens.

5. A pair of corneal contact lenses, comprising:

a first contact lens for one eye of a patient, said lens having a circular first correction zone, an annular second correction zone disposed concentrically around said first correction zone and an annular third correction zone concentrically disposed around said second correction zone, said first correction zone and said second correction zone having a common focal length, said second correction zone having a focal length different from said common focal length; and

a second contact lens for the other eye of the patient, said second contact lens having a fourth correction zone and a fifth correction zone, at least one of said fourth correction zone and said fifth correction zone being D shaped in a plan view of said second contact lens, one of said first correction zone and said one of said fourth correction zone and said fifth correction zone constituting a distant vision correction zone and the other of said first correction zone and said one of said fourth correction zone and said fifth correction zone constituting a near vision correction zone.

6. A pair of monovision type corneal contact lenses, comprising:

a distant vision contact lens for one eye of a patient, said lens having a distant vision correction zone extending throughout a major portion of said lens, said distant vision correction zone having a first focal length, said lens having at least one first auxiliary correction zone with a second focal length different from said first focal length, a portion of said distant vision correction zone coextensive with the pupil of said one eye covering more than approximately two-thirds of the area of the pupil of said one eye in essentially any operative disposition of said contact lens on said eye and with essentially any size of said pupil; and

a near vision contact lens for the other eye of the patient, said lens having a n ar vision correction zon

extending throughout a major portion of said lens, said near vision correction zone having a third focal length, said lens having at least one second auxiliary correction zone with a fourth focal length different from said third focal length, a portion of said near vision correction zone coextensive with the pupil of said other eye covering more than approximately two-thirds of the area of the pupil of said other eye in essentially any operative disposition of said contact lens on said other eye and with essentially any size of the pupil of said other eye.

7. The pair of contact lenses defined in claim 6 wherein said first auxiliary correction zone and said second auxiliary correction zone are both annular.

8. The pair of contact lenses defined in claim 6 wherein said first auxiliary correction zone and said second auxiliary correction zone are both intermediate distance vision correction zones.

9. A corneal contact lens having a first vision correction zone with a first focal length and at least one second vision correction zone with a second focal length different from said first focal length, the lens having on an anterior side a continuous surface with essentially a single radius of curvature, the lens being provided on a posterior side with a cornea matching surface extending annularly along a periphery of said lens, said posterior side being further formed with a first concave surface having a first radius of curvature smaller than any radius of curvature of said cornea matching surface, said concave surface being radially spaced from a geometric center of said lens, said posterior side being formed with a second concave surface spaced from said cornea matching surface and having a second radius of curvature different from said first radius of curvature.

10. The contact lenses defined in claim 9 wh rein said first concave surface is annular.

11. The contact lenses defined in claim 9 wherein said first concave surface corresponds to an intermediate distance correction zone of the lens.

12. The contact lenses defined in claim 10 wherein said first concave surface is spaced from said cornea matching surface.

13. A pair of corneal contact lenses, comprising:

a first contact lens for one eye of a patient, said lens having a circular distant vision correction zone and an annular first auxiliary correction zone surrounding said distant vision correction zone, said distant vision correction zone having a first focal length, said auxiliary correction zone having a second focal length different from said first focal length; and

a second contact lens for the other eye of the patient, said second contact lens having a circular near vision correction zone and an annular second auxiliary correction zone surrounding said near vision correction zone, said near vision correction zone having a third focal length, said second auxiliary correction zone having a fourth focal length different from said third focal length, one of said first contact lens and said second contact lens having an annular third auxilary correction zone surrounding the respective one of said first auxiliary correction zone and said second auxiliary correction zone, said third auxiliary correction zone having a focal length substantially the same as the focal length of the circular correction zone of said one of said said first contact lens and said second contact lens.

14. The pair of contact lenses defined in claim 13 wherein said first auxiliary correction zone and said second auxiliary correction zone are intermediate distance correction zones.

15. A pair of multifocal corneal contact lenses, comprising:

a first contact lens for one eye f a patient, said lens having a first distant vision correction zone and a first

near vision correction zone; and

a second contact lens for the other eye of the patient, said second contact lens having a first correction zone and a second correction zone, said first correction zone corresponding at least generally in shape and location to said distant vision correction zone of said first contact lens, said second correction zone corresponding at least generally in shape and location to said near vision correction zone of said first contact lens, said first correction zone constituting a second near vision correction zone and said second correction zone constituting a second distant vision correction zone, at least one of said first contact lens and said second contact lens having an intermediate distance correction zone separating the distant vision correction zone from the respective near vision correction zone of said one of said first contact lens and said second contact lens.

16. The pair of contact lenses defined in claim 15 wherein said first distant vision correction zone occupies a circular area and said first near vision correction zone occupies an annular area disposed about said first distant vision correction zone, said second near vision correction zone occupying a circular area and said second distant vision correction zone occupying an annular area disposed about said second near vision correction zone.

17. The pair of contact lenses defined in claim 15 wherein said first distant vision correction zone, said first near vision correction zone, said second distant vision correction zone, and said second near vision correction zone are all substantially D-shaped in plan view of said first contact lens and said second contact lens.

18. A pair of multifocal corneal contact lenses, comprising:

a first contact lens for one eye of a patient, said lens having a distant vision correction zone, a near vision correction zone and an intermediate distance correction zone; and

a second contact lens for the other eye of the patient, said second contact lens having a first correction zone, a second correction zone and a third correction zone, said first correction zone corresponding generally in shape and location to said distant vision correction zone of said first contact lens, said second correction zone corresponding generally in shape and location to said near vision correction zone of said first contact lens, said third correction zone corresponding generally in shape and location to said intermediate distance correction zone of said first contact lens, one of said first correction zone, said second correction zone and said third correction zone having a focal length lying in the same focal range as the focal length of the corresponding zone of said first contact lens, the other two of said first correction zone, said second correction zone and said third correction zone each having a focal length lying in the same focal range as the one of the remaining two zones of said first contact lens having a size and location therein different from the size and location of the respective correcti n zone in said second contact lens, whereby said other two of said first correction zone, said second correction zone and said third correction zone are switched in location with respect to said first contact lens.

19. The pair of contact lenses defined in claim 18 wherein said distant vision correction zone, said near vision correction zone and said intermediate distance correction zone are all concentric with respect to each other, said first c rrection zone, said second correction zone and said third correction zone all being concentric with respect to each other.

20. The pair of contact lenses defined in claim 18 wherein two of said distant vision correction zone, said near vision correction zone and said intermediate distance correction zone and two of said first correction zone, said second correction zone and said third correction zone are essentially D-shaped in plan view of said first contact lens and said second contact lens.

21. A pair of multifocal corneal contact lenses, comprising:

a first contact lens for one eye of a patient, said lens having a first correction zone and a second correction zone concentrically disposed with respect to one another, said first correction zone being circular and said second correction zone being annular in plan view of said first contact lens, said first correction zone constituting a distant vision correction zone and said second correction zone constituting a near vision correction zone; and

a second contact lens for the other eye of the patient, said second contact lens having a third correction zone and a fourth correction zone concentrically disposed with respect to one another, said third correction zone being circular and said fourth correction zone being annular in plan view of said second contact lens, said third correction zone constituting a near vision correction zone and said fourth correction zone constituting a distant vision correction zone,

wherein said first correction zone and said third correction zone each have an area equal to at least approximately two-thirds of a minimum area subtended by the respective pupil of the patient.

22. The pair of contact lenses defined in claim 21 wherein a portion of said second correction zone and a portion of said fourth correction zone coextensive with the pupil of the respective eye in a maximally opened state of such pupil each cover an area equal approximately to at least two-thirds of the area subtended by the respective pupil in said maximally opened state.

23. A pair of multifocal corneal contact lenses, comprising:

a first contact lens for one eye of a patient, said lens having a circular first correction zone, an annular second correction zone disposed concentrically around said first correction z ne and an annular third correction zone concentrically disposed around said sec nd correction z ne, one of said first correction zone, said second correction zone and

said third correction zone constituting a distant vision correction zone, another of said first correction zone, said second correction zone and said third correction zone constituting a near vision correction zone, and yet another of said first correction zone, said second correction zone and said third correction zone constituting an intermediate distance correction zone; and

a second contact lens for the other eye of the patient, said second contact lens having a fourth correction zone and a fifth correction zone, one of said fourth correction zone and said fifth correction zone constituting a distant vision correction zone and the other of said fourth correction zone and said fifth correction zone constituting a near vision correction zone, at least one of said fourth correction zone and said fifth correction zone having a D shape in plan view of said second contact lens.

24. A multifocal corneal contact lens comprising a circular first correction zone, a second correction zone disposed on one side of said first correction zone and a third correction zone disposed on a side of said first correction zone opposite said second zone, said second correction zone and said third correction zone being separated at a substantial center of the contact lens by said first correction zone and being adjacent one another along a substantially diametrically extending line on opposite sides of said first correction zone, one of the three zones being a distant vision correction zone, another of the three zones being a near vision correction zone and a remaining one of the three zones being an intermediate distance correction zone.

25. A pair of multifocal corneal contact lenses, comprising:

a first contact lens for one eye of a patient, said lens having a first correction zone and second correction zone, said first correction zone having a focal length in a first focal range and said second correction zone having a focal length in a second focal range; and

a second contact lens for the ther eye of th

patient, said second contact lens having a third correction zone and a fourth correction zone, said third correction zone corresponding generally in size, shape and location to said first correction zone, said fourth correction zone corresponding generally in shape and location to said second correction zone, said third correction zone having a focal length in said second focal range and said fourth correction zone having a focal length in said first focal range, at least one of said first contact lens and said second contact lens having on an anterior side a continuous surface with essentially a single radius of curvature, said one of said first contact lens and said second contact lens being provided on a posterior side with a cornea matching surface extending annularly along a periphery of said lens, said posterior side being further formed with at least one concave surface having a radius of curvature smaller than any radius of curvature of said cornea matching surface, said concave surface being radially spaced from a geometric center of said lens.

26. A pair of multifocal corneal contact lenses, comprising:

a first contact lens for one eye of a patient, said lens having a first correction zone and second correction zone, said first correction zone having a focal length in a first focal range and said second correction zone having a focal length in a second focal range; and

a second contact lens for the other eye of the patient, said second contact lens having a third correction zone and a fourth correction zone, said third correction zone and said fourth correction zone each having a geometric configuration different from said first correction zone and said second correction zone, said third correction zone having a focal length in a third focal range and said fourth correction zone having a focal length in a fourth focal range different from said third focal range, at least one of said first contact lens and said second contact lens having on an anterior side a continuous surface with ssentially a single radius of curvature, said n of said first contact lens and said second contact lens being provided on a p sterior sile with a cornea

matching surface extending annularly along a periphery of said lens, said posterior side being further formed with at least one concave surface having a radius of curvature smaller than any radius of curvature of said cornea matching surface, said concave surface being spaced from a geometric center of said lens.

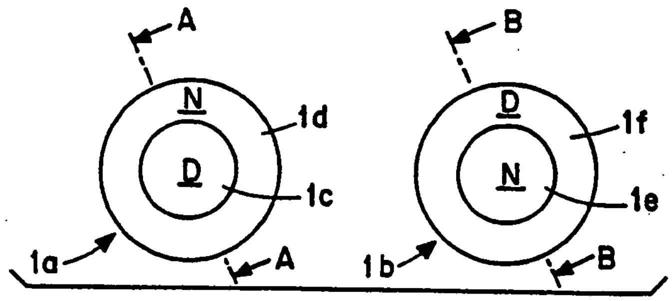


FIG. 1

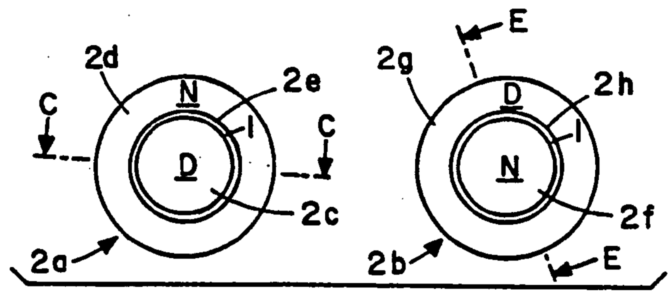


FIG. 2

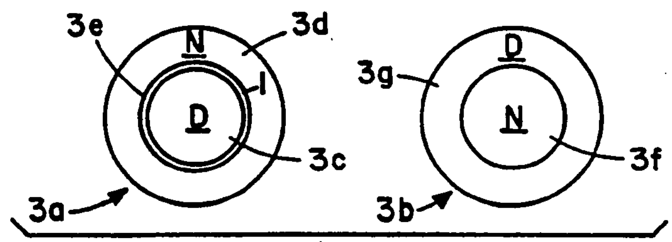


FIG. 3

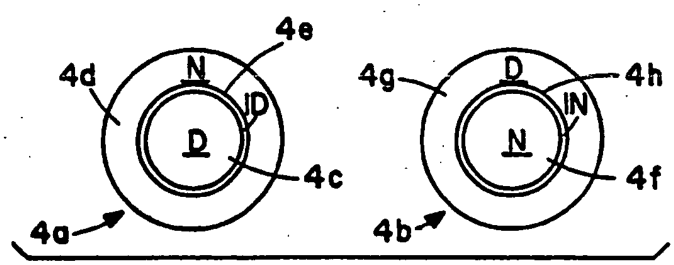


FIG. 4

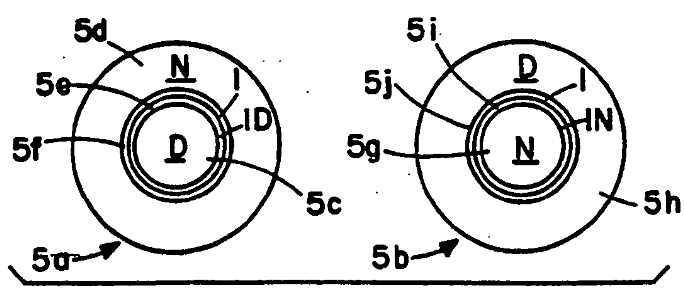


FIG. 5

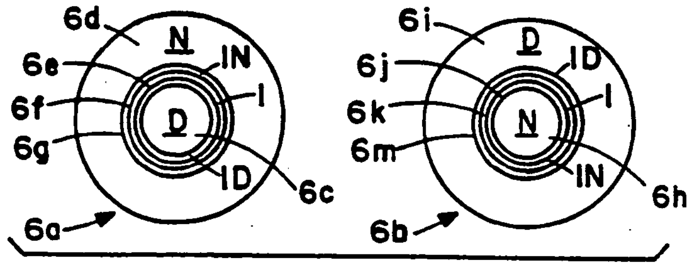


FIG. 6

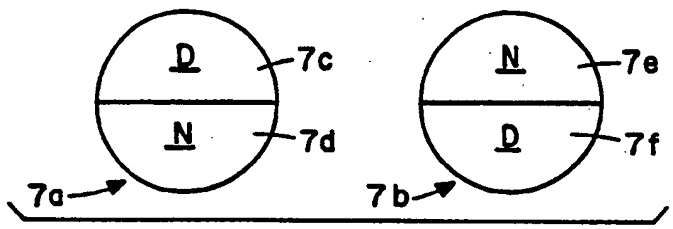


FIG. 7

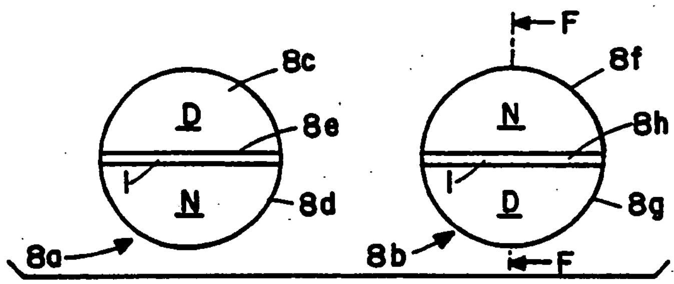


FIG. 8

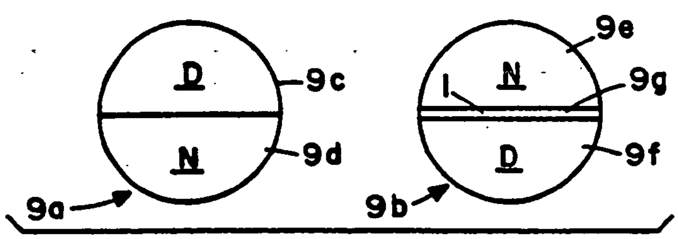


FIG. 9

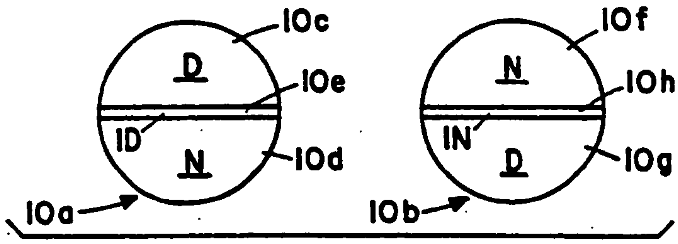


FIG. 10

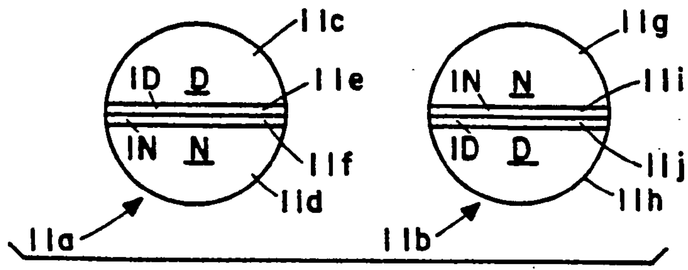


FIG. 11

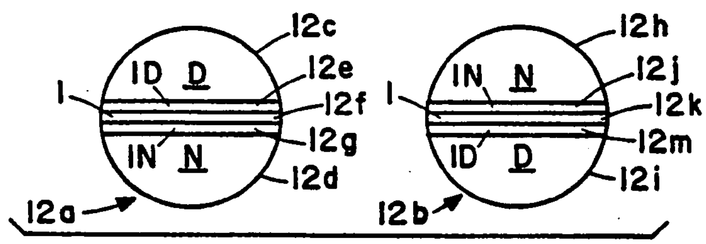


FIG. 12

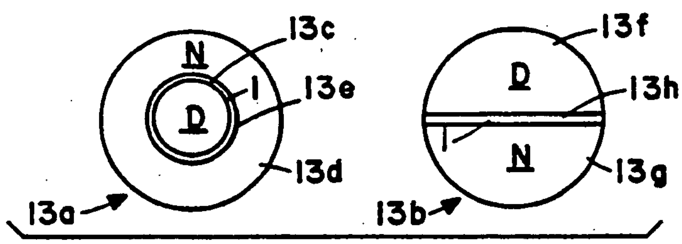


FIG. 13

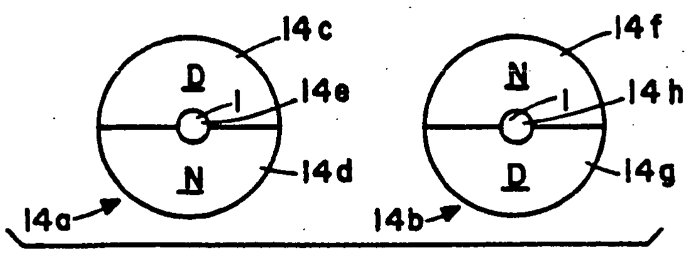


FIG. 14

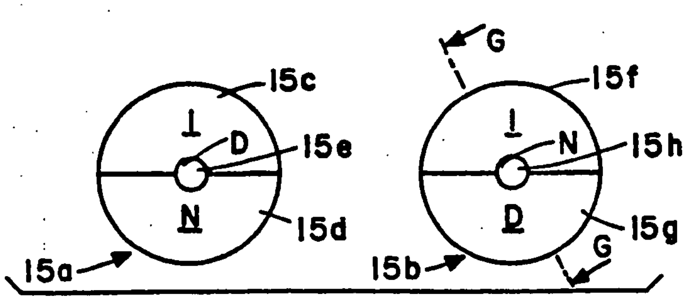


FIG. 15

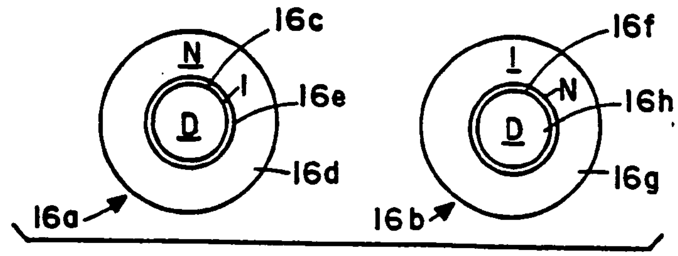


FIG.16

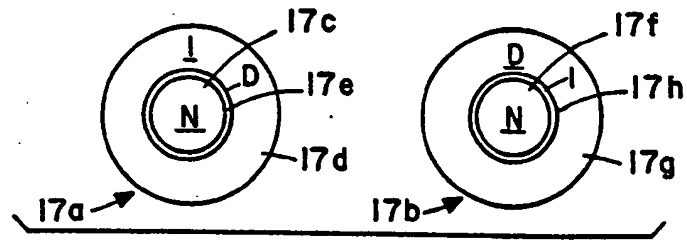


FIG. 17

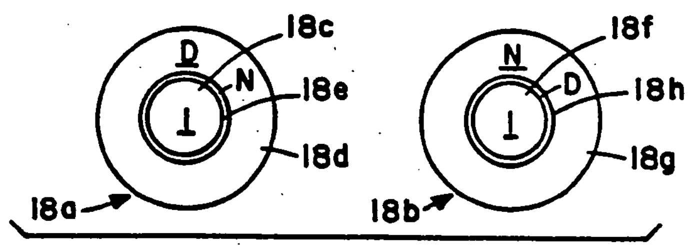


FIG. 18

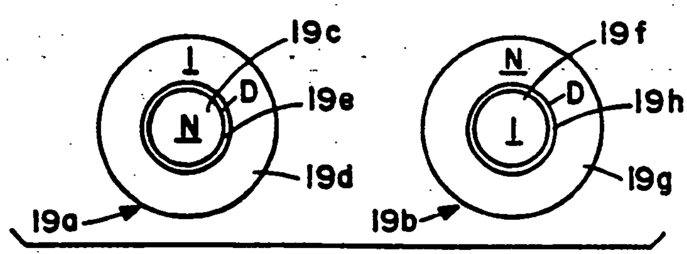


FIG. 19

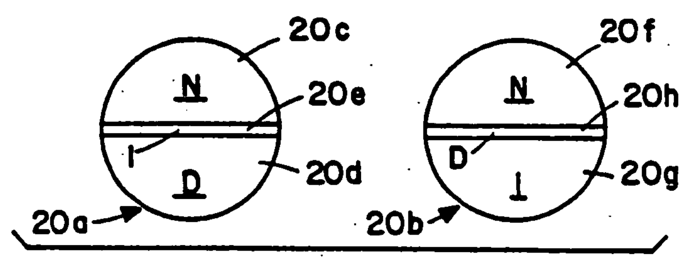


FIG.20

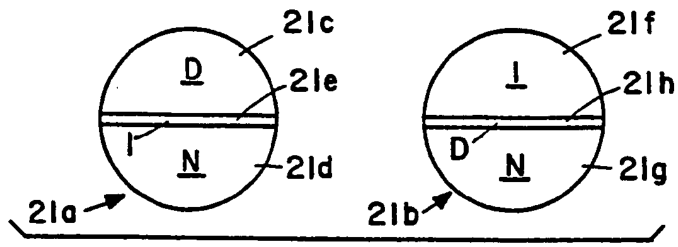


FIG. 21

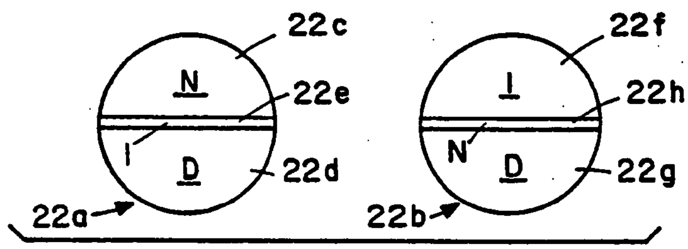


FIG. 22

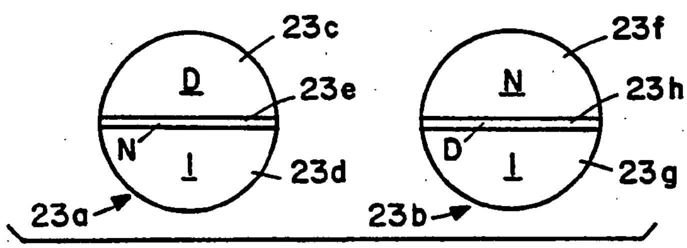


FIG. 23

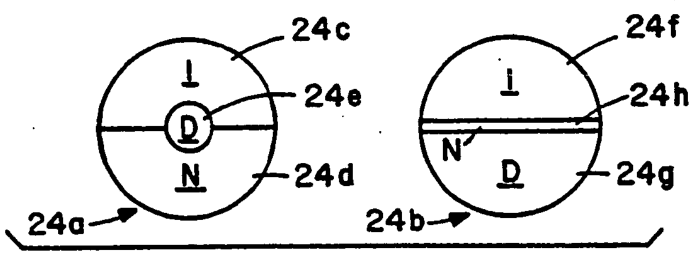


FIG. 24

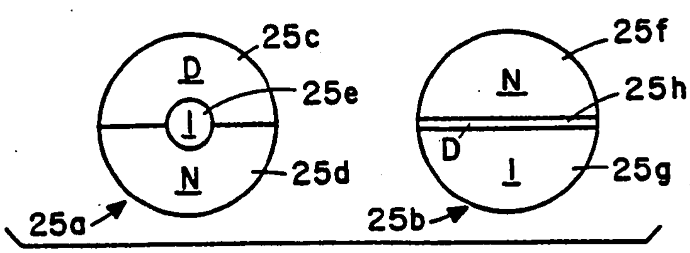


FIG. 25

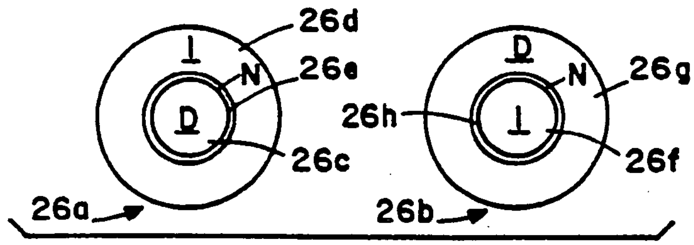


FIG. 26

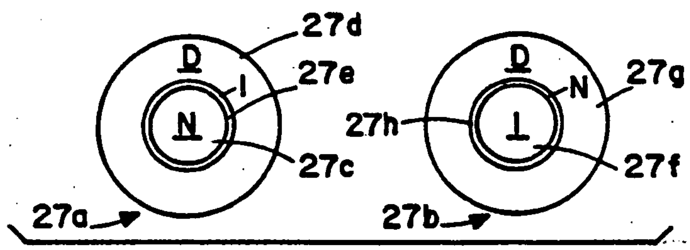


FIG. 27

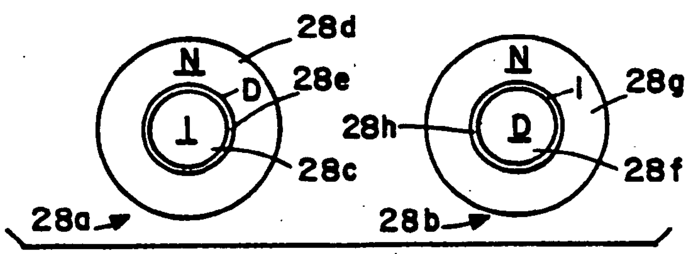


FIG.28

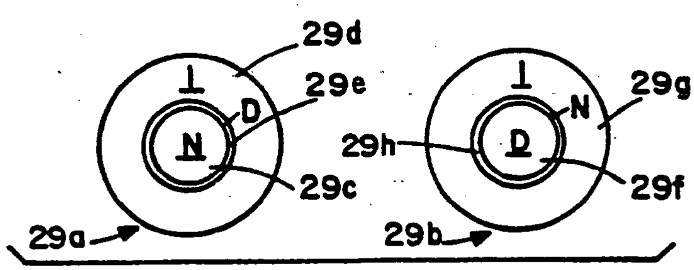


FIG.29

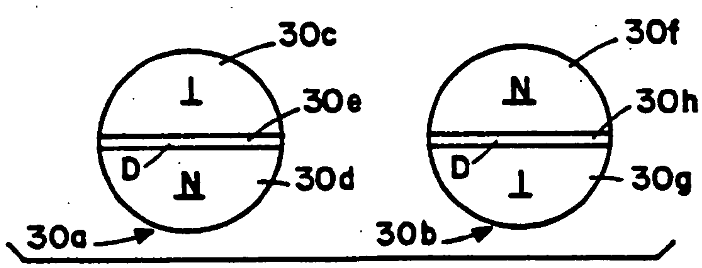


FIG.30

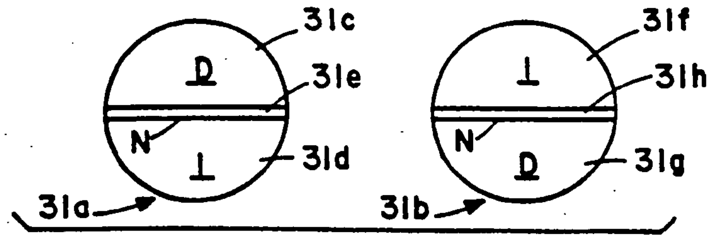


FIG. 31

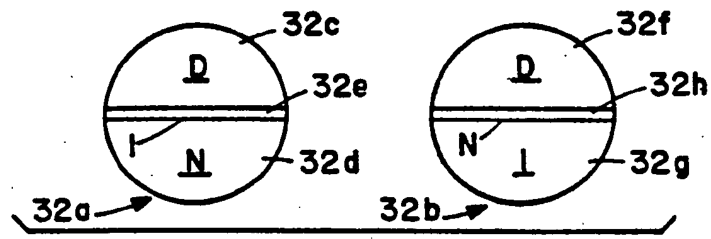


FIG. 32

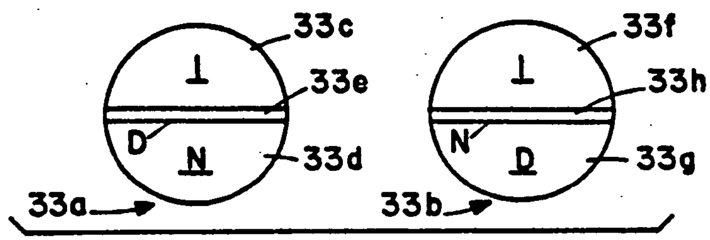


FIG. 33

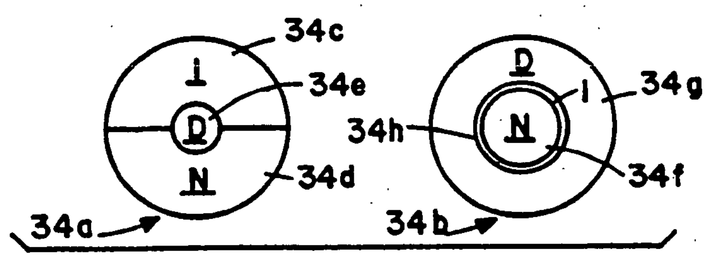


FIG. 34

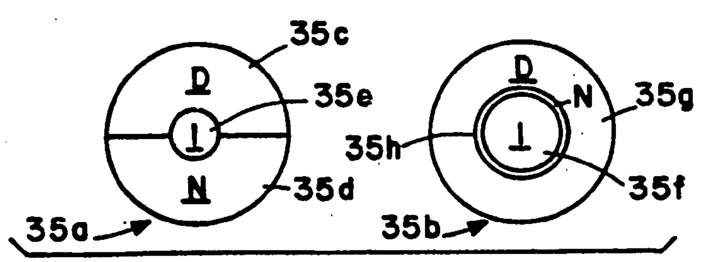


FIG. 35

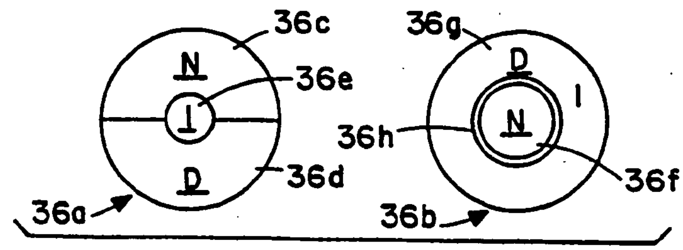


FIG. 36

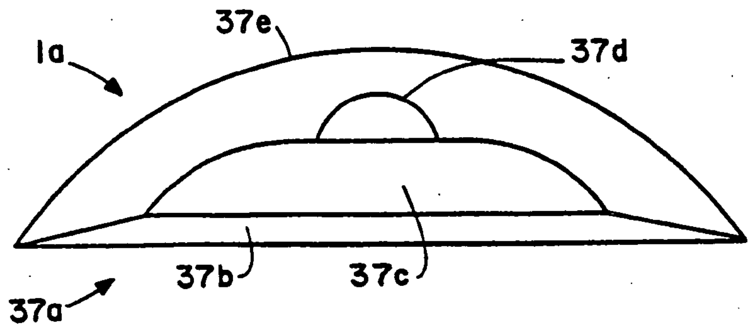


FIG. 37

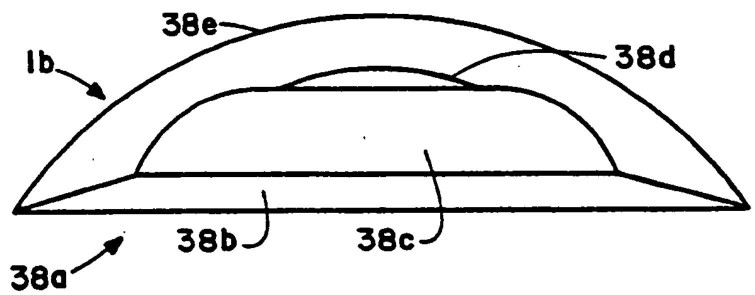


FIG. 38

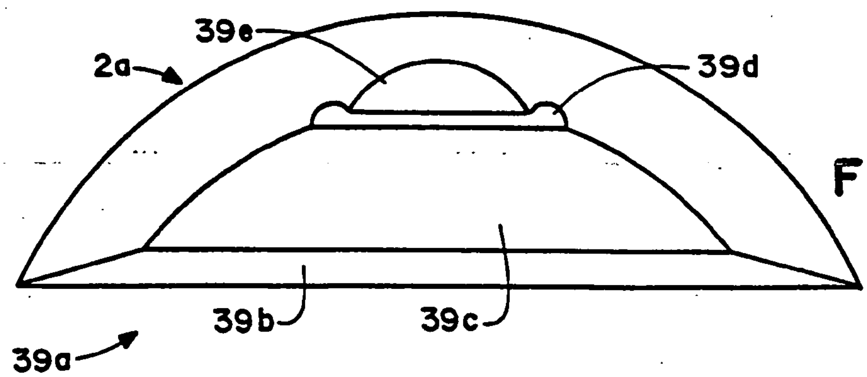


FIG. 39

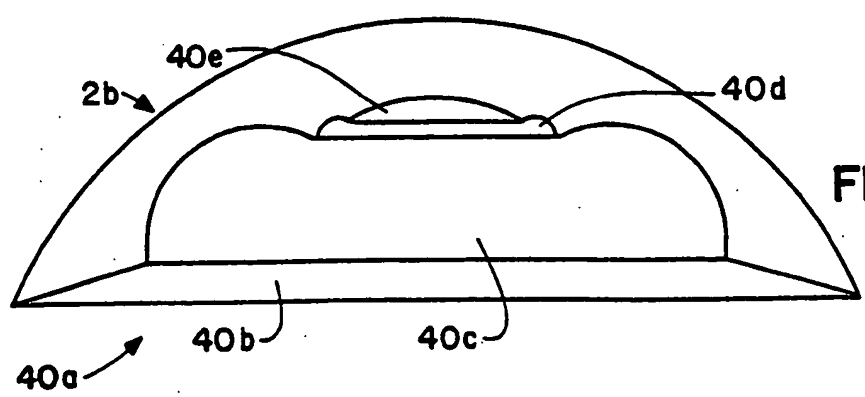


FIG. 40

SUBSTITUTE SHEET

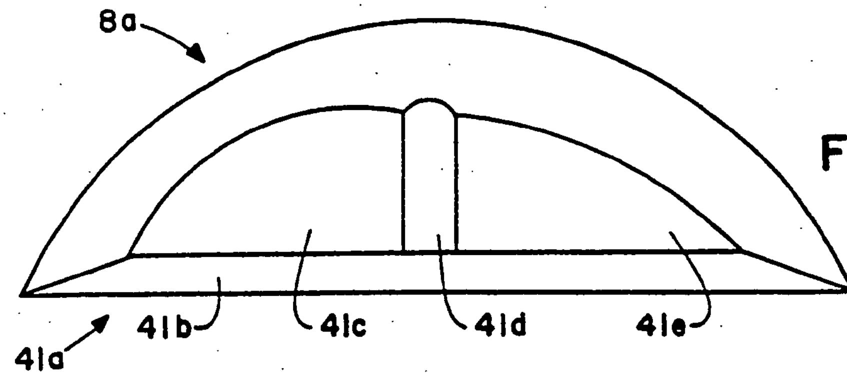


FIG. 41

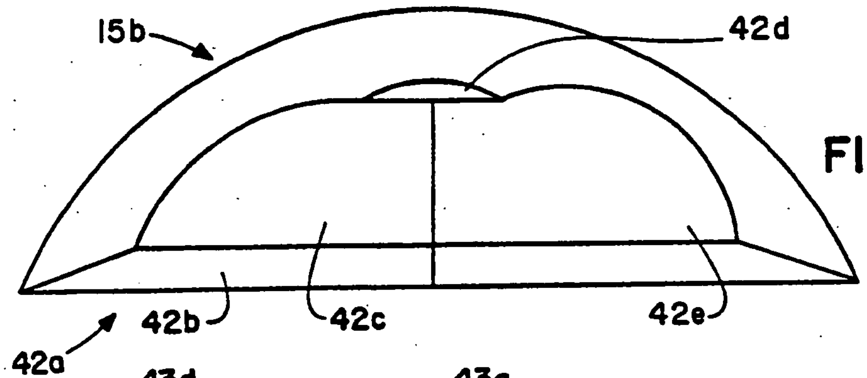


FIG. 42

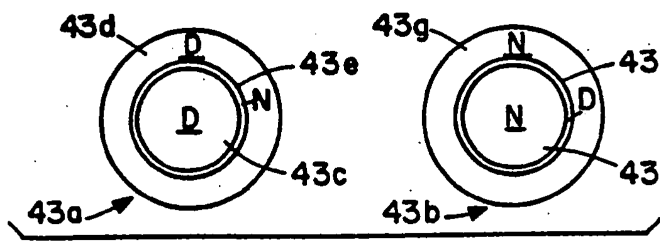


FIG. 43

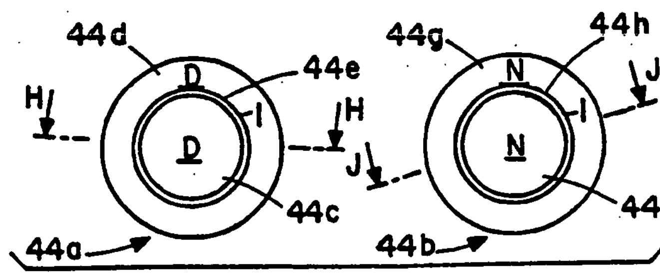


FIG. 44

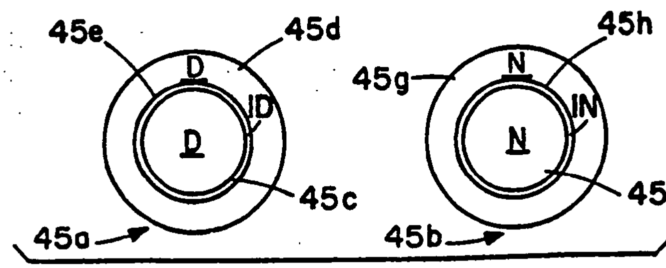


FIG. 45

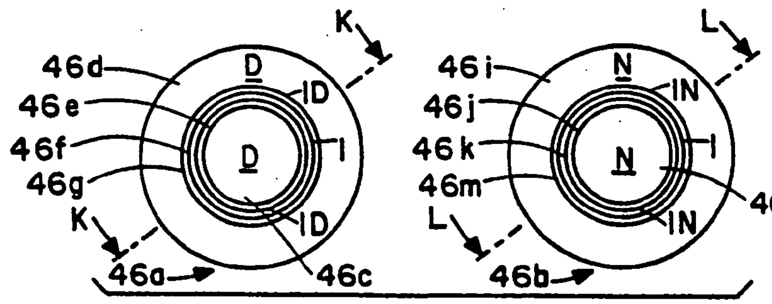


FIG. 46

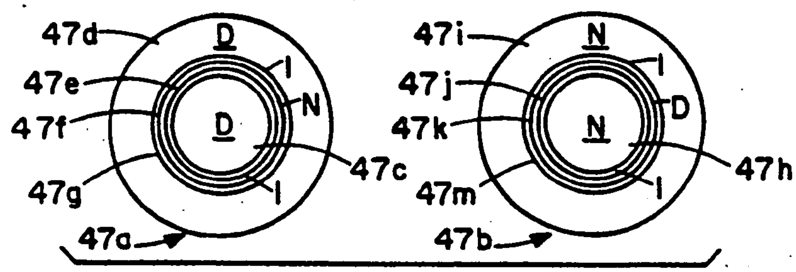


FIG. 47

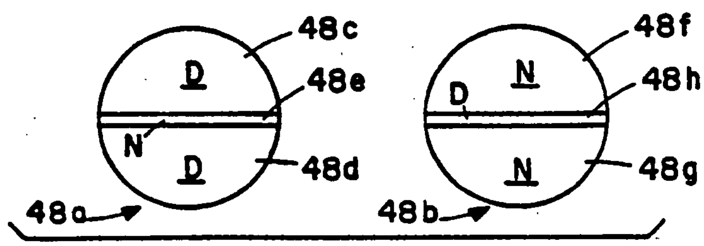


FIG. 48

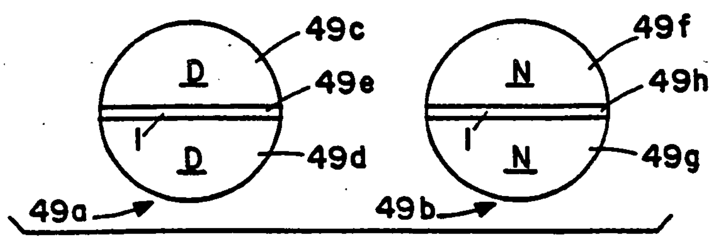


FIG. 49

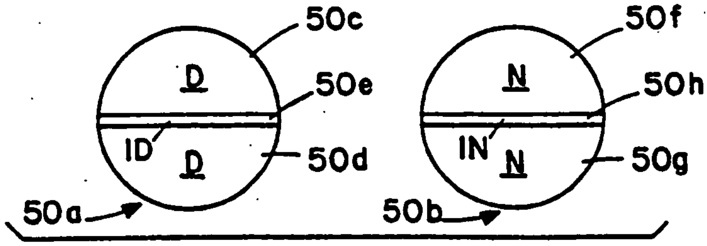


FIG. 50

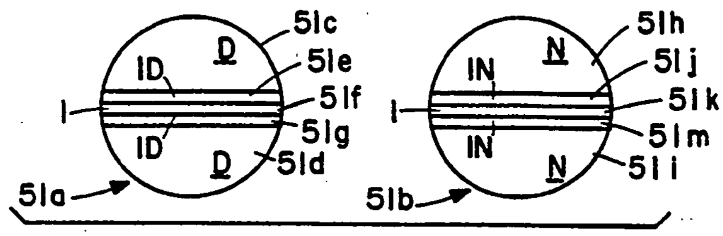


FIG. 51

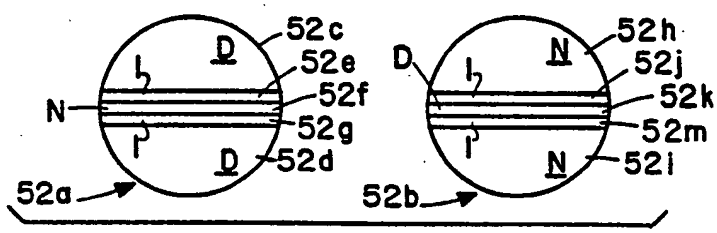


FIG. 52

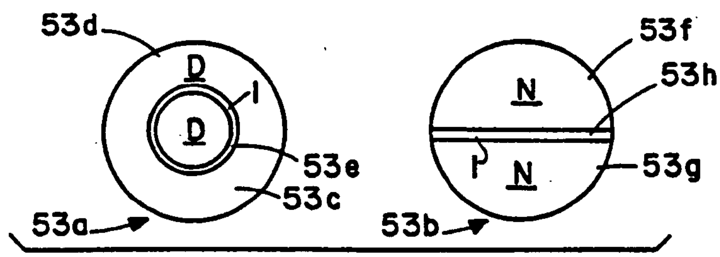


FIG. 53

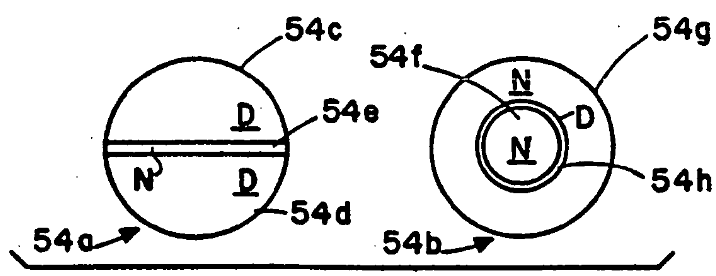


FIG. 54

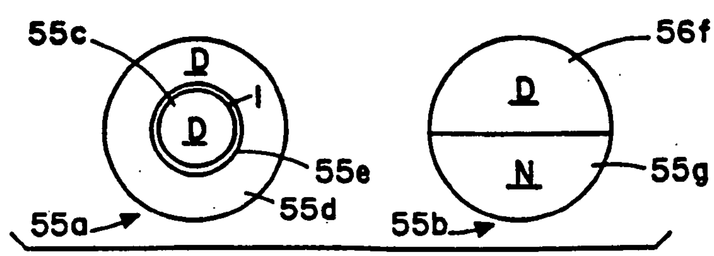


FIG. 55

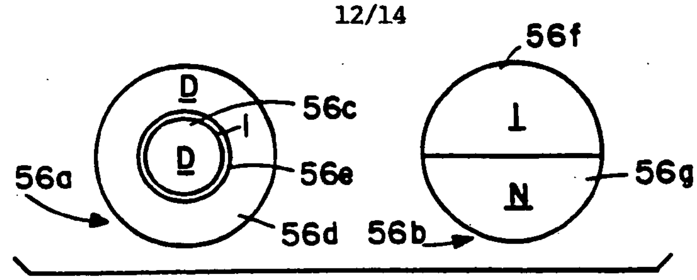


FIG. 56

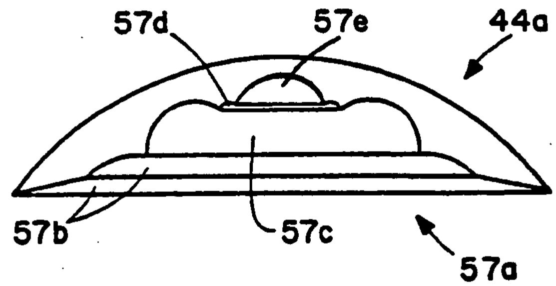


FIG. 57

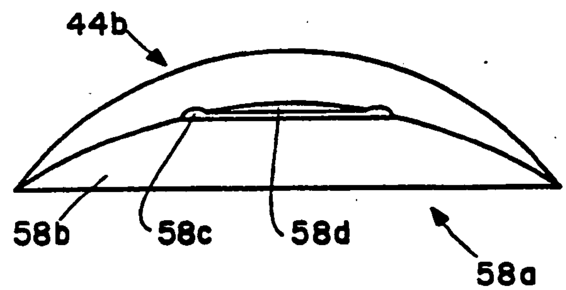


FIG. 58

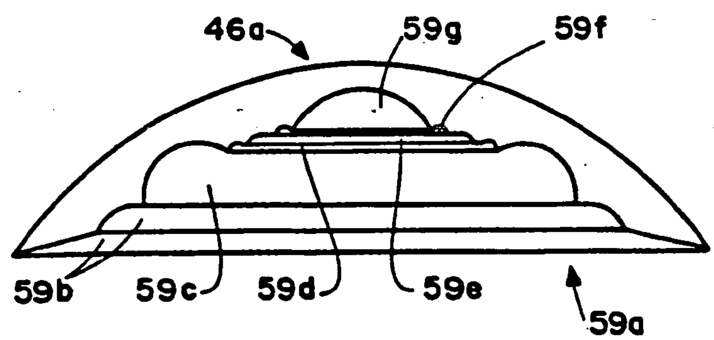


FIG. 59

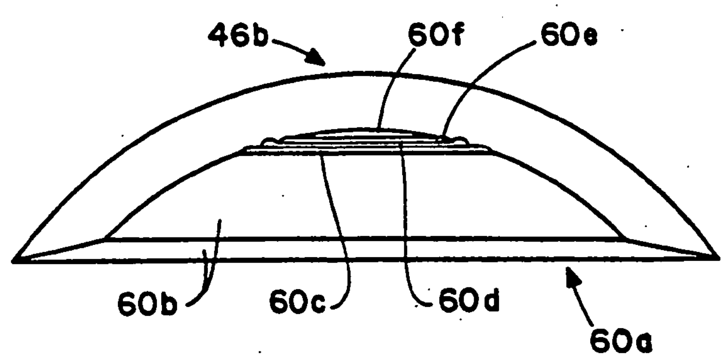


FIG. 60

SUBSTITUTE SHEET

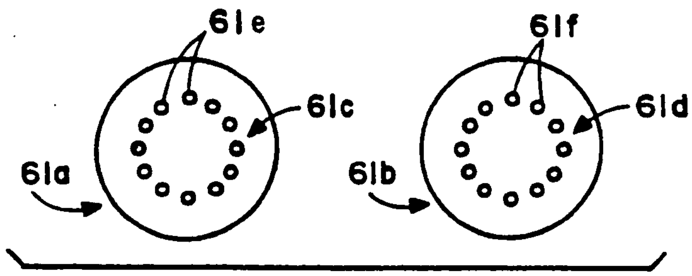


FIG. 61

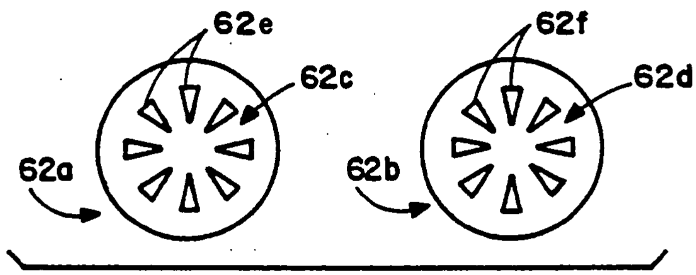


FIG. 62

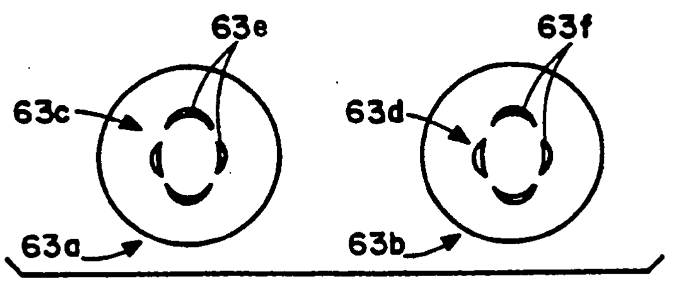


FIG. 63

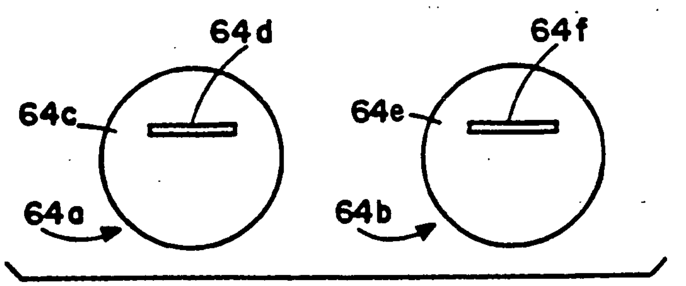


FIG. 64

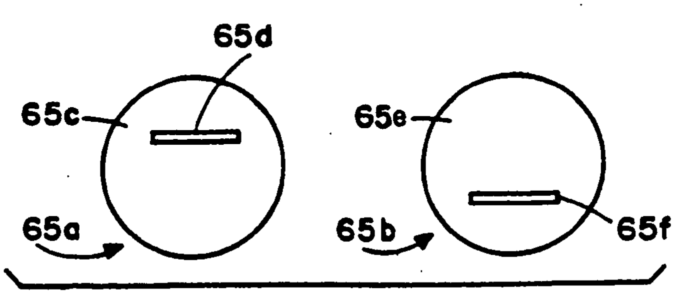


FIG. 65

SUBSTITUTE SHEET

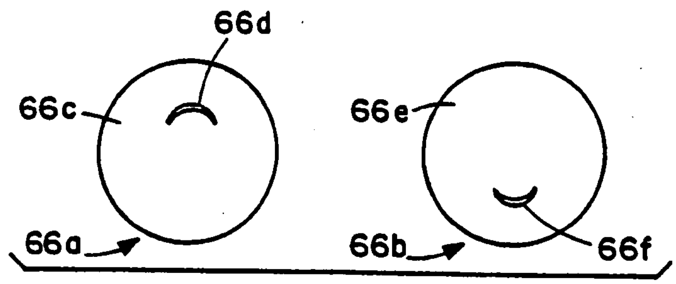


FIG. 66

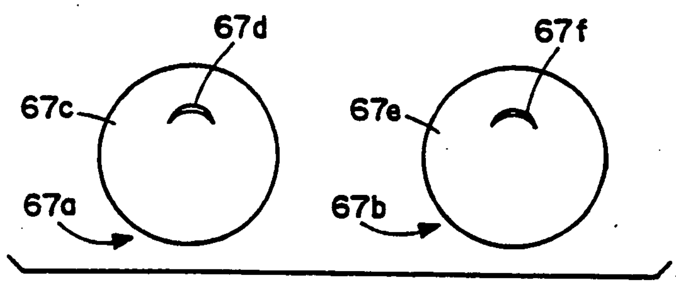


FIG. 67

INTERNATIONAL SEARCH REPORT

International Application No PCT/US90/07229

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC^5 : G02C 7/04
U.S. Cl. : 351/161

II. FIELDS SEARCHED

Minimum Documentation Searched

Classification System	Classification Symbols
U.S.	351/160.R, 160.H, 161, 162

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched

III. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
T	US, A, 4,923,296 (ERICKSON) 08 May 1990 (See entire document).	1-8 and 13-26
A	US, A, 4,795,462 (GRENDAHL) 03 January 1989 (See entire document).	1-8 and 13-26
A	US, A, 4,704,016 (de CARLE) 03 November 1987 (See entire document).	1-8 and 13-26
A	US, A, 4,636,049 (BLAKER) 13 January 1987 (See entire document).	6-8
A	EP, A, 0201231 (HOLDEN ET AL) 12 November 1986 (See entire document).	1-4, 6-8 and 13-26
A	US, A, 4,618,228 (BARON ET AL) 21 October 1986 (See entire document).	1-8 and 13-26
A	US, A, 4,525,043 (BRONSTEIN) 25 June 1985 (See entire document).	9-12
X	US, A, 4,418,991 (BREGER) 06 December 1983 (See col. 3, line 51-col. 4, line 24; col. 4, line 62-col. 5, line 22; col. 5, lines 53-58).	9-12

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search: 14 March 1991

Date of Mailing of this International Search Report: 15 APR 1991

International Searching Authority: ISA/US

Signature of Authorized Officer: Scott J. Sugarman

Form PCT/ISA/210 (second sheet) (May 1986)